Texas Medicaid Managed Care
Focus Study Addendum
Social Determinants of Health and Their Impact on Health Care Quality Measures in the STAR+PLUS Population

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Center for Health Care Data
School of Public Health
The University of Texas Health Science Center

The Institute for Child Health Policy
University of Florida,
The External Quality Review Organization
for Texas Medicaid Managed Care and CHIP

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ABBREVIATIONS

Agency for Healthcare Research and Quality	AHRQ
American Community Survey	ACS
Breast Cancer Screening	BCS
Centers for Disease Control and Prevention	CDC
Centers for Medicare and Medicaid Services	CMS
Children's Health Insurance Program	CHIP
Comprehensive Housing Affordability Strategy	CHAS
Concordance Statistic	C
Creating High-Quality Results and Outcomes Necessary to Improve Chronic Care Act	CHRONIC Care Act
Emergency Department	ED
External Quality Review Organization	EQRO
Health and Human Services Commission	HHSC
Healthcare Effectiveness Data and Information Set	HEDIS ®
Home and Community-Based Services	HBCS
Institute for Child Health Policy	ICHP
Local Area Transportation Characteristics for Households	LATCH
Long-Term Services and Support	LTSS
Managed Care Organization	MCO
National Committee for Quality Assurance	NCQA
Obstetrician-Gynecologist	OB-GYN
Pediatric Quality Indicators	PDI
Preventive Quality Indicator #90	PQI90
Primary Care Physician	PCP
Sexually Transmitted Disease	STD
Social Determinants of Health	SDOH
State of Texas Access Reform – Medicaid Managed Care	STAR
Use of Opioids from Multiple Providers	UOP-Multiple Providers

EXECUTIVE SUMMARY

As an addendum to the study titled, "Social Determinants of Health and Their Impact on Health Care Quality Measures in the CHIP and STAR/STAR Kids/STAR Health Populations", the same methods and analytic approach were used to evaluate the impact of social determinants of health (SDOH) on Medicaid health outcomes for the Texas STAR+PLUS adult population in 2018. Between this addendum and the study, the same comprehensive set of SDOH variables were analyzed; however, the selection of key health care quality measures differed in the addendum to represent the STAR+PLUS population. As in the study, this addendum evaluated the presence of significant associations and estimated the degree (as a percentage) to which individual SDOH variables contributed to the collective SDOH impact by analyzing the statistically significant associations between individual SDOH variables and the performance outcomes for each quality measure.

For the STAR+PLUS population, a total of eleven key health care quality measures were selected as study outcomes. The data for quality measures were compiled by the Texas Medicaid External Quality Review Organization (EQRO) and derived from Healthcare Effectiveness Data and Information Set (HEDIS®) and Agency for Healthcare Research and Quality (AHRQ) Prevention Quality Indicator (PQI) measure specifications using Medicaid claims, encounters, and enrollment data. A total of 24 SDOH variables were included in this addendum representing the following five categories: 1) "Demographic Attributes" (Race/Ethnicity), 2) "Health Behaviors", 3) "Availability and Access to Health Care Services", 4) "Social and Economic Environment", and 5) "Physical Environment". The SDOH variables were reported at the county level and obtained from valid public data sources (e.g., administrative data, census data, survey data, and public health surveillance data). Since the datasets used for this addendum included member-level county information, the quality measures data and SDOH variables data were linked and analyzed at the county level. Additional information about the quality measures and SDOH variables included in this addendum (e.g., data sources and measure specifications) can be found in Appendices I and II.

In this addendum, the analytic approach began with evaluating whether the addition of SDOH variables increased the statistical model's ability to predict the inclusion of members in the numerator of quality measures more accurately than random chance and better than a model that only included demographic variables. Next, this addendum analyzed the extent to which individual

SDOH variables were significantly associated with meeting the numerator criteria of each quality measure for the STAR+PLUS population. Additionally, since Medicaid managed care members covered under the Home and Community-Based Services (HCBS) Waiver were a unique subpopulation of the STAR+PLUS population, this addendum also stratified the analyses and results for the HCBS Waiver subpopulation. Detailed information about the analytic approach can be found in the Methods section.

Based on the addendum results, when SDOH variables were included in the statistical modeling for the STAR+PLUS population, as well as when stratified by the HCBS Waiver subpopulation, the model's ability to predict whether a member met the numerator criteria for quality measures increased and was more accurate than the model with demographic variables alone. In other words, comprehensively, the study and addendum's overall finding suggested that the social context in which Medicaid managed care members lived, as represented by the set of SDOH variables, was important to better understanding performance outcomes on key health care quality metrics, such as NCQA HEDIS® and AHRQ PQI measures. Additionally, similar to the results in the study, this addendum found that the number of individual SDOH variables with significant associations varied by quality measure, highlighting that although the social context was an important overall consideration, not every SDOH variable contributed equally to the observed impact of SDOH on quality measure performance in the STAR+PLUS population and the HCBS Waiver subpopulation. Moreover, based on the categorization of SDOH variables, "Social and Economic Environment" was the SDOH category showing the largest categorical influence on the performance outcomes of the quality measures for the STAR+PLUS population and the HCBS Waiver subpopulation.

While there was not one unique SDOH variable significantly associated with all quality measures for the STAR+PLUS population and HCBS Waiver subpopulation, Rate of Violent Crime, Rate of Children in Poverty, and Rate of Adult Obesity were significantly associated with the most quality measures overall. However, the relative influence of violent crime, children in poverty, and adult obesity varied per quality measure; for instance, for the Comprehensive Diabetes Care: Eye Care quality measure, although Rate of Violent Crime was significantly associated with this quality measure, the relative influence of violent crime was less than the relative influence of food insecurity, which was also significantly associated with this quality measure. Although further research would be needed to better understand if a single unique SDOH

variable may be the most influential on all performance outcomes for a given Medicaid population, these findings may suggest that identifying a single influential SDOH variable is less important than understanding that there are significant associations between SDOH variables and quality measures for Medicaid populations.

When interpreting the results of this addendum, similar limitations apply to this addendum as to the study since the methodological approach was identical. The SDOH variables used in this addendum were collected from a variety of data sources, and as such, the greatest common level of analysis was conducted at the county level, which may not necessarily reflect the social context of the individual Medicaid member and may mask differences within a county and any individual exposures. Furthermore, as a cross-sectional study design, while the results indicated that there were significant associations between individual SDOH variables and the performance outcomes of quality measures, the results could not be interpreted as direct causal relationships.

Given these limitations, several recommendations could be considered by policy makers, Medicaid MCOs, and providers that would not only address the STAR+PLUS population but also align across Medicaid managed care populations. For example, this addendum also supports the recommendation that access to member-level SDOH data could further improve the accuracy of statistical modeling as well as help identify which individual SDOH variables are significantly associated with quality measure performance at the member-level. Member-level SDOH data could be standardized and collected during Medicaid enrollment, via health care diagnostic codes related to SDOH (e.g., Z codes) documented by providers, or using member surveys by Medicaid MCOs. Regardless of the approach, mutual engagement and buy-in among policy makers, providers, and MCOs is essential. Alternatively, another recommendation would be to build off this addendum's findings to prioritize interventions and strategies addressing SDOH for STAR+PLUS and HCBS Waiver members. For example, prioritization could be based on the largest SDOH categorical influence (e.g., the SDOH variables within the SDOH category "Social and Economic Environment") or an individual SDOH variable of significant influence on a quality measure of interest. For example, higher Rate of Adult Smoking in the community was found to be significantly associated with Emergency Department Utilization among STAR+PLUS members and with higher Acute Inpatient Utilization among both STAR+PLUS members and HCBS Waiver subpopulation. Tracking and monitoring first or second-hand smoking exposure

could help inform interventions on smoking cessation, whether direct patient intervention or community level ones.

As policy makers, MCOs, and providers look to better understand the impact of SDOH on Medicaid health outcomes, this addendum provided important findings supporting the relevance of SDOH variables collectively and individually on key measures of health care quality for the STAR+PLUS population and HCBS Waiver subpopulation. By expanding upon the study, this addendum comprehensively supports the development of a statewide approach for continuously improving the quality of health care delivered to all Medicaid beneficiaries, including children, adolescents, pregnant women, and adults in Texas Medicaid.

INTRODUCTION

As defined by the World Health Organization, social determinants of health (SDOH), the "conditions in which people are born, grow, live, work and age"[1], are gaining recognition as significant contributors to overall health status. Examples of SDOH include housing conditions, food insecurity, available transportation to health care services, social norms and attitudes, and other socio-economic conditions[2,3], and SDOH can be grouped into five major categories: "Demographic Attributes", "Health Behaviors", "Availability and Access to Health Care Services", "Social and Economic Environment", and "Physical Environment." Research indicates that unmet social needs, such as food insecurity, unstable housing, and poverty, can negatively impact health status and serve as risk factors for many chronic diseases such as diabetes, obesity, and depression.[4,5] One study found that the estimated number of deaths in the United States attributable to SDOH, such as low education, racial segregation, low social support, and income inequality, was comparable to the number of deaths attributed to heart disease, cerebrovascular disease, and lung cancer.[6] A national initiative, known as Healthy People 2020, outlined a 10-year strategy for improving the health of all populations and recommended moving the focus of health care beyond treating diseases to addressing the SDOH contributing to disease states.[7] Moreover, the Centers for Disease Control and Prevention (CDC) emphasizes that addressing SDOH is necessary for achieving health equity.[2]

According to a national Medicaid survey by the Kaiser Family Foundation, Medicaid managed care organizations (MCOs) are increasingly engaging in activities addressing SDOH for their members.[8] A number of states now require Medicaid MCOs to screen members for certain social needs and refer members to social services as needed.[9,10] There are emerging efforts by

hospitals, providers, and health plans to address SDOH through innovative payment models, provider education regarding SDOH, and coordination with community-based organizations in the social services sector.[9-11] Additionally, national studies on Medicaid managed care populations have shown that investing in SDOH initiatives results in cost savings through decreased rates of unnecessary hospital readmissions and emergency department (ED) visits.[12,13] A 2018 case-control study conducted on Medicaid and Medicare Advantage members revealed that the members who were connected with social services showed a 10% reduction in health care costs.[12] Additionally, a study conducted by the Robert Woods Johnson Foundation revealed a significant reduction in costs when SDOH were addressed, as observed by a 17% reduction in ED utilization, 26% reduction in ED spending, 53% reduction in inpatient spending, and 23% reduction in outpatient spending.[14]

With an estimated population of 29 million people[15], Texas is the second most populated state in the United States, and the Texas Health and Human Services Commission (HHSC) administers Medicaid health benefits to approximately 4.3 million individuals.[16] While the vast majority of Texas Medicaid members are children and pregnant women (e.g., 44% of all state resident children and 52% of all state births), other Medicaid beneficiaries include adults with disabilities or people over age 65 who meet the income eligibility requirement (e.g., income up to 74% of the federal poverty level).[16] About 15 percent of elderly individuals in Texas live below the poverty rate[17] and almost 13 percent of the adult population lives with an identified disability[18]; HHSC provides Medicaid coverage to these populations through the STAR+PLUS managed care program.

Since 95% of Texas Medicaid beneficiaries are enrolled in Medicaid managed care, the Medicaid MCOs in Texas are key partners in supporting initiatives that address SDOH to improve the health status of their members. Five Medicaid managed care organizations (MCOs) manage the care and coordinate services for individuals enrolled in the STAR+PLUS program, including primary, acute, and behavioral health care as well as pharmacy and long-term services and support (LTSS). Moreover, through the Home and Community-Based Services (HCBS) Waiver program, STAR+PLUS beneficiaries eligible for nursing facility care can receive LTSS tailored to promote integration within the community and avoid institutionalization. Individuals in the STAR+PLUS and HCBS Waiver programs have complex care needs that incur high costs,[18] and at the state level, understanding the impact of SDOH on these Medicaid populations is an important step towards

developing a statewide approach for continuously improving the quality of health care delivered to all Medicaid members. This addendum expands on the study's initial focus on children, adolescents, and pregnant women in Texas Medicaid to include a focus on older adults and adults with disabilities in Texas Medicaid.

Background

In 2017, approximately 4.7 million Americans age 65 and older lived in poverty.[19] Poverty and other SDOH have been shown to affect quality of life and disparate access to providers and rehabilitation services, particularly among elderly individuals and individuals with disabilities.[20, 21] The conditions and environment in which older adults live have also been shown to affect life expectancy.[22] Low socioeconomic status and poor environmental safety have been associated with high rates of morbidities and mortality among elderly individuals,[23] while adequate social connections, food security, and financial stability have been shown to lower health care utilization and costs associated with this population.[22, 24-27]

With increasing national attention on SDOH, many health care payers have looked to assess the impact of SDOH on various health outcomes. For example, the Improving Medicare Post-Acute Care Transformation (IMPACT) Act of 2014 (H.R. 4994)[28] created an initiative to study the effect of socioeconomic status on quality, resource use, and other performance-based measures for individuals in the Medicare program. The National Committee for Quality Assurance (NCQA) conducted a similar analysis on Medicare Advantage plans and found that while socioeconomic status did not significantly impact the results for some quality measures, socioeconomic status did contribute to a disparity in results for other quality measures[29]. Moreover, the Creating High-Quality Results and Outcomes Necessary to Improve Chronic (CHRONIC) Care Act of 2017 (S.870) was passed by Congress as a bipartisan effort to better respond to the needs of Medicare Advantage beneficiaries with chronic illnesses, allowing health plans to design supplemental benefits that "have a reasonable expectation of improving or maintaining the health or overall function"[30,32] of beneficiaries, which potentially includes interventions addressing SDOH issues. Building off these analyses, this addendum assessed the impact of SDOH on key health care quality measures for the Texas Medicaid STAR+PLUS adult population.

To participate in federal funding for Medicaid managed care programs, the Centers for Medicare & Medicaid Services (CMS) requires external quality review (EQR) by an organization independent from the state. Since 2002, the Institute for Child Health Policy at the University of

Florida has served as the external quality review organization (EQRO) for Texas Medicaid and the Children's Health Insurance Program (CHIP). Following CMS guidance for EQR Protocol 6, the EQRO reports quality measures for Texas Medicaid and CHIP MCOs each reporting year. The quality measures derive from nationally recognized quality assessment programs including the NCQA, which developed a set of quality measures for the managed care industry known as the Healthcare Effectiveness Data and Information Set (HEDIS®),[33] and the Agency for Healthcare Research and Quality (AHRQ), which developed quality measures known as Prevention Quality Indicators (PQI) and Pediatric Quality Indicators (PDI).[34] In Texas Medicaid and Children's Health Insurance Program (CHIP), these nationally recognized quality measures serve as key indicators of MCO and provider performance on the delivery of high quality care to Medicaid members. Therefore, the Medicaid member enrollment data and quality measures data available through the EQRO presented an excellent opportunity to evaluate the association between SDOH variables and key health care quality measures on Texas Medicaid managed care populations, including children, adolescents, and pregnant women in Medicaid and CHIP and older adults and adults with disabilities in Medicaid STAR+PLUS.

Objective and Aims

The objective of this addendum was to evaluate the impact of a comprehensive set of SDOH variables on key health care quality measures for the Texas Medicaid STAR+PLUS population in 2018, as well as stratify the analyses by the HCBS Waiver subpopulation. The aims of this addendum were to analyze significant associations between the SDOH variables and the quality measures and to estimate the degree (as a percentage) by which individual SDOH variables significantly contributed to the overall impact of SDOH on the performance outcomes of the quality measures.

METHODS

Data

The Medicaid member enrollment data provided basic demographic information such as age, gender, race/ethnicity, and county of residence on eligible STAR+PLUS and HCBS Waiver members for this addendum. The claims and encounter data were used to identify STAR+PLUS and HCBS Waiver members who met the criteria for denominator and numerator inclusion in the quality measures.

Study Outcomes – Quality Measures

A total of eleven key health care quality measures were selected as study outcomes for the STAR+PLUS adult population in this addendum (see **Table 1**). Since each quality measure includes distinct age, program enrollment, or disease diagnosis specifications, only eight of the eleven quality measures were applicable when stratifying the analyses by the HCBS Waiver subpopulation (see quality measures indicated with an asterisk in **Table 1**).

As defined by HEDIS® or AHRQ, each quality measure included numerator and denominator specifications that defined whether high quality health care was delivered to an eligible individual. When the performance criteria for the numerator or denominator are satisfied, as defined by the measure specifications, then an eligible individual may be counted in the numerator or denominator values for a given quality measure. For instance, for the Comprehensive Diabetes Care: Eye Care quality measure, an eligible Medicaid member, who had received a retinal eye exam as defined by the measure specifications, would satisfy the performance criteria to count towards the numerator. In most instances, quality measure specifications are defined such that satisfying the numerator performance criteria results in an overall rate that represents high quality health care (e.g., the Comprehensive Diabetes Care: Eye Care measure represents those receiving appropriate diabetes preventive care). However, quality measures may also be defined such that satisfying the numerator performance criteria results in an overall rate that represents low quality health care. For instance, the Emergency Department (ED) Utilization quality measure has inverse performance directionality in that satisfying the numerator performance criteria means that an ED visit for ambulatory care occurred, which represents low quality health care or an unfavorable health outcome. Of note, for some of the quality measures, the rates are originally reported in units of member months (e.g., ED Utilization is reported as the number of ED visits per 1,000-member months); however, in this addendum, rather than using member months, the binary outcome of the event was identified per individual (e.g., member had an ED visit or did not have an ED visit).

In **Table 1**, each of the quality measures selected for the STAR+PLUS adult population (and those for the HCBS Waiver subpopulation, as indicated by an asterisk) are listed by measure title, measure description, and measure source. Additional information regarding the quality measures included in this addendum can be found in Appendix II.

Table 1: Study Outcomes

Study Outcomes – STAR+PLUS Adults *Study Outcomes used for the HCBS Waiver subpopulation are indicated with an asterisk (*)*		
Quality Measure	**Measure Description**	**Source**
Emergency Department (ED) Utilization *	This measure summarizes utilization of ambulatory care, specifically for ED visits. Numerator criteria include members with ED utilization during measurement year.	HEDIS®
Acute Inpatient Utilization *	This measure summarizes utilization of acute inpatient care services in the following category: total inpatient discharges (sum of maternity, surgery, and medicine). Numerator criteria include members with an acute inpatient admission during measurement year.	HEDIS®
All-Cause 30-Day Readmissions *	This measure summarizes acute inpatient stays that were followed by an unplanned acute readmission for any diagnosis within 30 days. Numerator criteria include members with an unplanned re-admission within 30 days of initial inpatient stay.	HEDIS®
Overall Composite Admissions Rate (Prevention Quality Indicator 90) *	This measure summarizes admissions for diabetes with short-term complications, diabetes with long-term complications, uncontrolled diabetes without complications, diabetes with lower-extremity amputation, chronic obstructive pulmonary disease, asthma, hypertension, heart failure, bacterial pneumonia, or urinary tract infection, all of which are often considered preventable admissions. Numerator criteria include members with at least one of the listed preventable admissions within the measurement year.	AHRQ
Identification of Alcohol and Other Drug (AOD) Services *	Numerator criteria includes members with an alcohol and other drug (AOD) related claim who received the following chemical dependency services during the measurement year: inpatient, intensive outpatient or partial hospitalization, outpatient or an ambulatory Medication Assisted Treatment (MAT) dispensing event, ED, telehealth, or any service.	HEDIS®
Adults' Access to Preventive/Ambulatory Health Services	This measure summarizes adults 20 years and older who had an ambulatory or preventive care visit during the measurement year. For this addendum, numerator criteria include members 21 years and older with an ambulatory or preventive care visit during the measurement year.	HEDIS®

Study Outcomes – STAR+PLUS Adults *Study Outcomes used for the HCBS Waiver subpopulation are indicated with an asterisk (*)*		
Quality Measure	**Measure Description**	**Source**
Annual Monitoring for Patients on Persistent Medication	This measure summarizes adults 18 years and older who received appropriate treatment (see Appendix II) for medication therapy during the measurement year. For this addendum, numerator criteria include members 21 years and older who received at least 180 treatment days of ambulatory medication therapy for a therapeutic agent during the measurement year and at least one therapeutic monitoring event for the therapeutic agent in the measurement year.	HEDIS®
Comprehensive Diabetes Care: Eye Care *	This measure summarizes adults 18-75 years of age with diabetes (type 1 and type 2) who had an eye exam (retinal) performed. For this addendum, numerator criteria include members 21-75 years of age with Type 1 or Type 2 diabetes with a retinal eye exam performed.	HEDIS®
Breast Cancer Screening *	This measure summarizes age-appropriate breast cancer screening for women 50-74 years of age. Numerator criteria include women 50-74 years of age with a mammogram screening in the last 2 years.	HEDIS®
Follow-Up after Hospitalization for Mental Illness	This measure summarizes adults 21 years of age and older with a follow-up visit within 30 days of hospital discharge for mental illness. Numerator criteria include members 21 years of age and older who were hospitalized for treatment of selected mental illness diagnoses and had a follow-up visit with a mental health practitioner within 30 days of discharge.	HEDIS®
Use of Opioids from Multiple Providers *	Numerator criteria includes members 21 years of age and older, receiving prescription opioids for 15 days during the measurement year from multiple providers.	HEDIS®

Independent Variables - Social Determinants of Health (SDOH) Variables

For analytic consistency, the same set of 24 SDOH variables included in the study for children, adolescent, and pregnant women populations were also included in this addendum as the independent variables for the STAR+PLUS population. The selected SDOH variables represented socioeconomic, environmental, and behavioral determinants relevant across all study populations. The data for the SDOH variables were obtained from a variety of valid public data sets including:

- Administrative data: Data collected and maintained to document the provision of services or programs to individuals.

- Census data: Data collected by the United States Federal Statistical System to assess the nation's people and economy.

- Survey data: Data collected from individuals and organizations through survey methods recording subjective responses about living conditions and the health of the community.

- Public health surveillance data: Data collected to report the occurrence of public health events or health conditions, monitor community health problems, and inform public health policy and strategies.

Due to the range of data sets accessed for the SDOH variables data, the smallest common level for analysis was at a county level. Moreover, since county of residence was available in the STAR+PLUS enrollment data, the SDOH variables data and quality measures data were linked and analyzed at the county level.

Additionally, the SDOH variables were grouped into the following five SDOH categories:

- Demographic Attributes: Demographic attributes are variables related to the individual member. Gender and Age were used as control variables. Race/Ethnicity was the only demographic attribute assessed as an individual SDOH variable within this SDOH category, and Race/Ethnicity was assessed in all statistical models.

- Health Behaviors: Health behaviors as SDOH variables are expressed as rates within the community that reflect lifestyle actions that affect health outcomes (such as Rate of Physical Inactivity) or lifestyle actions that increase one's risk of disease (such as Rate of Adult Smoking and Rate of Sexually Transmitted Disease (STD)).

- Availability and Access to Health Care Services: Access to affordable, quality, and timely health care services can help prevent diseases and detect health issues sooner, enabling individuals to live longer, healthier lives. The SDOH variables within this category represent the availability of medical providers within a geographic area, such as primary care physicians and specialty care physicians.

- Social and Economic Environment: The SDOH variables within this category represent the socioeconomic conditions of a community, such as income levels, educational attainment, employment status, safety, and degree of social supports, which can significantly affect the health and expected lifespan of individuals living within the community.

- Physical Environment: The quality and infrastructure of the physical environment that individuals live and work directly and indirectly impact health outcomes through the air they breathe, water they drink, housing they live in, and transportation available for work and school.

In **Table 2**, each of the 24 SDOH variables assessed in the statistical models are listed and grouped under one of the five SDOH categories. Additional details regarding the SDOH variables included in this addendum can be found in Appendix I.

Table 2: Social Determinants of Health (SDOH) Variables by SDOH Category

Demographic Attributes
Race/Ethnicity
Health Behaviors
Access to Exercise Opportunities
Rate of Sexually Transmitted Disease (STD)
Rate of Teen Births
Rate of Adult Smoking
Rate of Adult Obesity
Rate of Physical Inactivity
Availability and Access to Health Care Services
Access to Primary Care Physicians (PCP)
Transportation
Access to Mental Health Providers
Access to OB/GYN (obstetrics and gynecology) Providers
Rate of Uninsured Adults
Social and Economic Environment
Rate of High School Graduation
Rate of Unemployment
Food Insecurity
Rate of Children in Single-Parent Households
Rate of Violent Crime
Rate of Injury Deaths
Rate of Children in Poverty
Rate of Disconnected Youth
Availability of Social Associations
Physical Environment
Air Pollution

| Rate of Severe Housing Problems |
| Lead Exposure |

ANALYSIS

The analyses were conducted to evaluate the contribution of each SDOH variable (the independent variables) to the likelihood of a member meeting the numerator criteria for each quality measure (the dependent variables). SDOH variables data were available in varying unit measurements, either as a percentage, a rate per 1000, a count, or a number, all of which designated a reporting value for that SDOH variable at the county level. To account for variations in measurement units and scale, the SDOH variables were standardized by Z-scores that were used in logistic regression models for each of the quality measures assessed. The SDOH variables were also attributed to the 254 counties within Texas, and multiple imputation was used to account and approximate for any null or missing SDOH values for some counties. Thus, the SDOH variables were assigned to each member based on the member's county of residence.

For the Race/Ethnicity SDOH variable, this demographic information was available through member enrollment data. As categorized in the member enrollment data, race/ethnicity was assessed in the statistical models using White/Non-Hispanic as the reference group compared to Hispanic, Black, American Indian/Alaskan, Pacific Islander/Asian, and "Unknown/Other".

Originally, three separate SDOH variables for food insecurity were included in the preliminary exploration of selected SDOH variables; however, these three SDOH variables, Food Environment Index, Food Desert, and Food Insecurity (Hunger Scale), were found to be strongly correlated with each other ($\rho > 0.8$). In order to reduce variance between these three SDOH variables, only Food Insecurity (Hunger Scale) was ultimately included in the statistical modeling and results of this addendum (as was similarly done in the study), while Food Environment Index and Food Desert were excluded.

After the preliminary data exploration assessing multi-collinearity in the independent SDOH variables, a stepwise approach was used to build various logistic models using SDOH variables to increase model outcome predictability while reducing error. Concordance (C) statistics were used to determine the quality and accuracy of the model. Concordance statistics are often used to assess the ability of a model to predict an outcome and identify the degree of randomness between pairs of observations. The concordance index (C-statistic) is a measure used to assess a logistic regression's ability to predict an outcome using the variables included in the model. C is

calculated using two values, percent of concordance pairs and percent of tied pairs. To determine those values, probabilities (scores) are calculated for each observation using the equation created by the model. The score for every observation with the outcome of interest (inclusion in the numerator) is compared to every observation without the outcome of interest (exclusion from the numerator). If the observation in the numerator has a higher score than the observation excluded from the numerator, the pair is "concordant." If the observation in the numerator has a lower score than the observation excluded from the numerator, the pair is "discordant." If the two observations have the same score, the pair is "tied." The percent of concordance is the percent of pairs that are "concordant," or where the predicted probability for an observation with the outcome (inclusion in the numerator) is higher than the predicted probability of an observation without the outcome (not included in numerator). C is then calculated as the sum of the number of concordant pairs and half the number of tied pairs divided by the total number of pairs. C is often compared to the area under the curve. A C-value is used as a measure of accuracy for the model such that a C-value of 0.50 corresponds to the model randomly predicting the response, and a C-value of 1.0 corresponds to the model perfectly discriminating the response.[35-36]

There were three steps in the creation of each model. First, a model including only control demographic variables of age and gender was developed. Second, a model adding all of the SDOH variables was developed. Third, a final model was developed including only those SDOH and demographic variables found to be significantly associated with the dependent variable. Concordance statistics were then calculated for each of the three models, and this analytic process was repeated for each quality measure for the STAR+PLUS population as well as stratified by the HCBS Waiver subpopulation.

The relative contribution of each individual SDOH variable to the overall impact of SDOH on the given dependent variable (quality measure) was computed by taking the absolute value of the regression coefficient divided by the sum of the absolute values of all coefficients.

RESULTS

Overall, the results of this addendum were consistent with the results of the study in that that when SDOH variables were included in the modelling for the STAR+PLUS population and the HCBS Waiver subpopulation, the model's ability to predict inclusion in the numerator of the quality measure increased and was more accurate than when the model only included demographic variables (age and gender). Such results suggested that these SDOH variables influence quality

measure performance to some degree, even for the STAR+PLUS population and the HCBS Waiver subpopulation. Additionally, similar to the study results, in this addendum, the number of individual SDOH variables with significant associations varied per quality measure, highlighting that not every SDOH variable contributed equally to the observed impact of SDOH on quality measure performance for the STAR+PLUS population and the HCBS Waiver subpopulation.

However, in contrast to the study results, the addendum results found that age and gender, as demographic variables, were also strong individual contributors to predicting the quality measures results for the STAR+PLUS adult population. For instance, older age was significantly associated with almost all of the quality measures, except for Follow-up after Hospitalization for Mental Illness and Use of Opioids from Multiple Providers which were associated with younger age and except for All-Cause 30-Day Readmissions, which was not significantly associated with age. of Since aging is expected to be an aggravating risk factor to health status, it may not be surprising that in the STAR+PLUS population, especially among members with disabilities and pre-existing conditions, age played a significant role on quality measure performance. Regarding gender, women were significantly associated with almost all of the quality measures except for Identification of AOD Services and All Cause 30-Day Readmissions, which were associated with men. The stronger effect of age and gender in this addendum than in the study may not be surprising given that the children, adolescent, and pregnant women populations, by definition, include age and gender restrictions, making the effect of age and gender considerably less significant.

STAR+PLUS Adults

In **Table 3**, the percent concordance and associated C-values for the three different models are shown for each of the eleven quality measures for the STAR+PLUS population: a) the model using demographic variables alone (e.g., gender and age), b) the model adding all 24 SDOH variables (e.g., gender, age, and SDOH variables), c) the model including only the SDOH and demographic variables found to be statistically significant (e.g. significant gender and age and significant SDOH variables). Based on the STAR+PLUS results in **Table 3**, for all eleven quality measures, the percent concordance of the model increased when SDOH variables were added, in comparison to when only demographic variables were included, indicating that adding SDOH variables increased the model's ability to accurately predict the performance outcomes for all quality measures and was not due to random chance (i.e., C-value >0.50).

As shown in **Table 3**, the degree of accuracy of each model is reflected in the size of the percent concordance, which varied by quality measure. For example, when the models included SDOH variables, the percent concordance ranged from 55.52% for All-Cause 30-Day Readmissions to 68.50% for Adults' Access to Preventive/ Ambulatory Health Services, meaning a model including SDOH variables was able to accurately predict readmissions 56% of times and receipt of a recommended adult preventive care visits 69% of times for the STAR+PLUS population. The degree of change between models with and without SDOH variables is reflected in the percent concordance differentials. For example, the percent concordance differential when adding SDOH variables was largest for Breast Cancer Screening at +6.70 percentage points, meaning that in comparison to a model only including demographic variables, a model including SDOH variables increased in accuracy by 6.70 percentage points (or 12% in c-value) for predicting receipt of breast cancer screening among STAR+PLUS adults. For most of the quality measures, further restricting the model to include only statistically significant SDOH and demographic variables did not make a meaningful change in the model's accuracy, as seen by the minimal difference in percent concordance between models with all SDOH variables and models with only significant SDOH variables. In fact, none of the SDOH variables were found to be significantly associated with All-Cause 30-Day Readmissions in the STAR+PLUS population (however, as shown in **Table 4**, when this result was stratified by the HCBS Waiver subpopulation, one SDOH variable, Air Pollution, was found to be significantly associated with All-Cause 30-Day Readmissions). Of note, even though adding SDOH variables increased the model's accuracy in predicting quality measure performance, even as demographic variables alone, age and gender were found to be significant contributors to the observed associations for several quality measures, particularly those measuring health care utilization (i.e., large percent concordance values for Adults' Access to Preventive/Ambulatory Health Services, Overall Composite Admissions Rate (PQI 90), Acute Inpatient Utilization, and Identification of Alcohol and Other Drug (AOD) Services).

Table 3: STAR+PLUS Adults – Comparison of Three Models using Percent Concordance and C-values

	Emergency Department (ED) Utilization			Acute Inpatient Utilization		
	Age and Gender	All SDOH	Significant SDOH	Age and Gender	All SDOH	Significant SDOH

	56.90%	58.80%	58.80%	60.00%	60.40%	60.20%
Percent Concordance						
C-value	0.57	0.59	0.59	0.60	0.60	0.60

	All-Cause 30-Day Readmissions			**Overall Composite Admissions Rate (Preventive Quality Indicator 90)**		
	Age and Gender	All SDOH	Significant SDOH	Age and Gender	All SDOH	Significant SDOH
Percent Concordance	52.50%	55.52%	N/A	65.20%	66.00%	65.40%
C-value	0.52	0.55	N/A	0.65	0.66	0.65

	Identification of Alcohol and Other Drug (AOD) Services			**Adults' Access to Preventive/ Ambulatory Health Services**		
	Age and Gender	All SDOH	Significant SDOH	Age and Gender	All SDOH	Significant SDOH
Percent Concordance	64.60%	66.00%	66.00%	66.60%	68.50%	68.20%
C-value	0.65	0.66	0.66	0.67	0.69	0.68

	Annual Monitoring for Patients on Persistent Medication			**Comprehensive Diabetes Care: Eye Care**		
	Age and Gender	All SDOH	Significant SDOH	Age and Gender	All SDOH	Significant SDOH
Percent Concordance	56.90%	60.20%	59.30%	57.20%	59.80%	59.40%
C-value	0.57	0.60	0.59	0.57	0.60	0.59

	Breast Cancer Screening			**Follow-Up after Hospitalization for Mental Illness**		
	Age and Gender	All SDOH	Significant SDOH	Age and Gender	All SDOH	Significant SDOH
Percent Concordance	51.70%	58.40%	56.60%	54.30%	60.40%	59.50%
C-value	0.52	0.58	0.57	0.54	0.60	0.60

	Use of Opioids from Multiple Providers		
	Age and Gender	All SDOH	Significant SDOH
Percent Concordance	55.90%	60.20%	60.10%
C-value	0.56	0.60	0.60

Home and Community-Based Services (HCBS) Waiver Adults Subpopulation

In this addendum, a total of 247,479 STAR+PLUS members were evaluated, and 17,411 of these individuals were also enrolled in the HCBS Waiver for six months or more during the

measurement year (2018). Of the eleven quality measures analyzed for the STAR+PLUS population, eight quality measures with were used to stratify the results by the HCBS Waiver subpopulation; the three other quality measures could not be used to stratify results due to insignificant denominator or numerator volume, which would underpower the analysis at the county level. Additional information on the HCBS Waiver subpopulation are included in Appendix IV, such as the total number of HCBS Waiver members (and non-HCBS enrolled members) for each quality measure, the percentage of HCBS Waiver members (and non-HCBS enrolled members) included in the numerator for each quality measure, and whether the difference between HCBS Waiver members and non-HCBS enrolled members was statistically significant.

In **Table 4**, the percent concordance and associated C-values for the three different models are shown for each of the eight quality measures for the HCBS Waiver subpopulation: a) the model using demographic variables alone (e.g., gender and age), b) the model adding all 24 SDOH variables (e.g., gender, age, and SDOH variables), c) the model including only the SDOH and demographic variables found to be statistically significant (e.g. significant gender and age and significant SDOH variables). Similar to the findings for the STAR+PLUS population, based on the results stratified for the HCBS Waiver subpopulation in **Table 4**, the percent concordance of the model increased when SDOH variables were added, in comparison to when only demographic variables were included, indicating that adding SDOH variables increased the model's ability to accurately predict the performance outcomes for all quality measures and was not due to random chance (i.e., C-value >0.50).

As shown in **Table 4**, the degree of accuracy of each model is reflected in the size of the percent concordance, which also varied by quality measure for the HCBS Waiver subpopulation. For example, when the models included SDOH variables, the percent concordance ranged from 57.40% for All-Cause 30-Day Readmissions to 68.90% for Identification of (AOD) Services, meaning a model including SDOH variables was able to accurately predict readmissions 57% of times and receipt of a recommended alcohol and other chemical dependency services 69% of times for the HCBS Waiver subpopulation. The degree of change between models with and without SDOH variables is reflected in the percent concordance differentials. For example, the percent concordance differential when adding SDOH variables was largest for Breast Cancer Screening at +8.30 percentage points, meaning that in comparison to a model only including demographic variables, a model including SDOH variables increased in accuracy by 8.30 percentage points (or

18% in c-value) for predicting receipt of breast cancer screening among HCBS Waiver adults. For most of the quality measures, further restricting the model to include only statistically significant SDOH and demographic variables did not make a meaningful change in the model's accuracy, as seen by the minimal difference in percent concordance between models with all SDOH variables and models with only significant SDOH variables. Of note, while the findings seemed to trend consistently between the STAR+PLUS population and HCBS Waiver subpopulation, since the HCBS Waiver subpopulation size was smaller overall, the statistical power to stratify the results was lower than that for the STAR+PLUS population and should be interpreted more cautiously.

Table 4: HCBS Waiver Subpopulation – Comparison of Three Models using Percent Concordance and C values

	Emergency Department (ED) Utilization			Acute Inpatient Utilization		
	Age and Gender	All SDOH	Significant SDOH	Age and Gender	All SDOH	Significant SDOH
Percent Concordance	58.80%	61.50%	60.70%	55.70%	58.30%	57.20%
C-value	0.59	0.61	0.61	0.56	0.58	0.57

	All-Cause 30-Day Readmissions			Overall Composite Admissions Rate (Preventive Quality Indicator 90)		
	Age and Gender	All SDOH	Significant SDOH	Age and Gender	All SDOH	Significant SDOH
Percent Concordance	53.70%	57.40%	54.60%	60.20%	62.30%	60.60%
C-value	0.54	0.57	0.55	0.60	0.62	0.61

	Identification of Alcohol and Other Drug (AOD) Services			Comprehensive Diabetes Care: Eye Care		
	Age and Gender	All SDOH	Significant SDOH	Age and Gender	All SDOH	Significant SDOH
Percent Concordance	67.30%	68.90%	67.40%	55.90%	59.90%	57.60%
C-value	0.67	0.69	0.67	0.56	0.60	0.58

	Breast Cancer Screening			Use of Opioids from Multiple Providers		
	Age and Gender	All SDOH	Significant SDOH	Age and Gender	All SDOH	Significant SDOH
Percent Concordance	50.30%	58.60%	56.30%	53.70%	59.45%	54.50%
C-value	0.50	0.59	0.56	0.54	0.59	0.55

Results per Quality Measure

Building off the comparative modeling conducted in **Table 3** and **Table 4**, the next analytic steps evaluated the presence of significant associations between individual SDOH variables and each of the eleven quality measures for the STAR+PLUS population; these results were also stratified by the HCBS Waiver subpopulation for eight of the quality measures. Since many of the quality measures assessed for the STAR+PLUS population involved inverse performance directionality, to interpret the directionality of significant associations per quality measure, additional details regarding the directionality of each association are available in Appendix III and Appendix V for the STAR+PLUS population and HCBS Waiver subpopulation respectively, including the estimates of the model coefficients to show how the individual SDOH variables contributed to each quality measure and the directionality of this impact. An inverse directionality indicates an inverse association between the SDOH variable and the numerator criteria for the quality measure.

In the following subsections, the results for each of the eleven quality measures for the STAR+PLUS population along with the stratified results for the HCBS Waiver subpopulation are presented, describing which of the individual SDOH variables showed significant associations with the quality measures, the degree (as a percentage) to which the individual SDOH variable contributed to the collective impact of SDOH, and which corresponding SDOH categories were most impactful. While there was not one unique SDOH variable significantly associated with all quality measures for the STAR+PLUS population and HCBS Waiver subpopulation, Rate of Violent Crime, Rate of Children in Poverty, and Rate of Adult Obesity were significantly associated with the most quality measures overall. Based on the categorization of SDOH variables, "Social and Economic Environment" was the SDOH category showing the largest impact on the quality measures for the STAR+PLUS population as well as for the HCBS Waiver subpopulation.

Emergency Department (ED) Utilization

As shown in **Table 5**, seventeen SDOH variables were significantly associated with Emergency Department (ED) Utilization for STAR+PLUS adults, while eight SDOH variables had significantly associations when stratified by the HCBS Waiver subpopulation. The largest individual SDOH contributors on ED Utilization were Race/Ethnicity (10.85%) and Availability of Social Associations (9.84%) for STAR+PLUS population and Availability of Social Associations (21.47%) and Rate of High School Graduation (16.81%) for the HCBS Waiver

subpopulation. Based on the SDOH categories, the SDOH variables under the "Social and Economic Environment" category showed the largest categorical influence on quality measure performance for STAR+PLUS adults and stratified HCBS Waiver adults.

Interpretation: Among STAR+PLUS adults, Hispanic, Black, American Indian/Alaskan, Pacific Islander/Asian, and "Unknown/Other" individuals were more likely to have an ED visit compared to White/Non-Hispanic individuals. When stratified to HCBS Waiver adults, lower high school graduation rates were associated with higher ED visits. For STAR+PLUS and HCBS Waiver adults, greater availability of social associations was associated with higher ED visits, which was a surprising association. However, a review of the literature found that that while social supports had a significant effect on reducing hospital admissions, there was not any evidence of social supports reducing outpatient care or ED visits.[37,38]

Table 5: Significant SDOH Variables on Emergency Department (ED) Utilization

SDOH Category	SDOH Variable	Percent Contribution to Collective SDOH Impact	
		STAR+PLUS	HCBS Waiver
Demographic Attributes	Race/Ethnicity	10.85%	
Health Behaviors	Access to Exercise Opportunities	3.80%	
	Rate of Sexually Transmitted Infections (STD)	7.36%	13.00%
	Rate of Teen Births	4.44%	
	Rate of Adult Smoking	2.97%	
	Rate of Adult Obesity	4.58%	5.93%
	Rate of Physical Inactivity		8.26%
Availability and Access to Health Care Services	Access to Primary Care Physicians (PCP)		
	Transportation		
	Access to Mental Health Providers	5.19%	
	Access to OB/GYN Providers	2.37%	
	Rate of Uninsured Adults		
Social and Economic Environment	Rate of High School Graduation	4.23%	16.81%
	Rate of Unemployment	3.05%	
	Food Insecurity	4.13%	
	Rate of Children in Single-Parent Households	8.52%	
	Rate of Violent Crime	4.72%	7.52%
	Rate of Injury Deaths	7.77%	13.75%
	Rate of Children in Poverty	8.96%	13.27%
	Rate of Disconnected Youth		

SDOH Category	SDOH Variable	Percent Contribution to Collective SDOH Impact	
		STAR+PLUS	HCBS Waiver
	Availability of Social Associations	9.84%	21.47%
Physical Environment	Air Pollution	5.85%	
	Rate of Severe Housing Problems	5.17%	
	Lead Exposure		

Acute Inpatient Utilization

As shown in **Table 6**, five SDOH variables were significantly associated with Acute Inpatient Utilization for STAR+PLUS adults, while six SDOH variables had significant association when stratified by the HCBS Waiver subpopulation. The largest individual SDOH contributors on Acute Inpatient Utilization were Transportation (29.57%), Rate of Teen Births (22.66%), and Rate of Violent Crime (21.56%) for STAR+PLUS adults and Rate of Adult Smoking (22.02%), Rates of Sexually Transmitted Diseases (18.82%), and Access to Mental Health Providers (17.48%) for the HCBS Waiver subpopulation. Based on the SDOH categories, the SDOH variables under the "Health Behaviors" category showed the largest categorical influence on quality measure performance for STAR+PLUS and HCBS Waiver adults.

Interpretation: Among STAR+PLUS adults, higher rates of transportation (i.e., greater miles traveled per day), teen births, and violent crime were associated with increased acute inpatient visits. It is important to note that the Transportation SDOH variable was an estimate of a person's miles traveled per day, not an estimate of a person's means for independent transportation. Thus, the observed association between transportation and increased inpatient admissions may actually be more reflective of the urbanity or rurality of an individual's environment, i.e., greater miles traveled per day may reflect a more rural area with less availability or access to regular ambulatory care services, leading to increased inpatient utilization. When stratified to HCBS Waiver adults, higher rates of adult smoking, higher rates of STDs, and less access to mental health providers were associated with increased acute inpatient visits.

Table 6: Significant SDOH Variables on Acute Inpatient Utilization

SDOH Category	SDOH Variable	Percent Contribution to Collective SDOH Impact	
		STAR+PLUS	HCBS Waiver
Demographic Attributes	Race/Ethnicity		

SDOH Category	SDOH Variable	Percent Contribution to Collective SDOH Impact	
		STAR+PLUS	HCBS Waiver
Health Behaviors	Access to Exercise Opportunities		
	Rate of Sexually Transmitted Infections (STD)		18.82%
	Rate of Teen Births	22.66%	
	Rate of Adult Smoking	14.56%	22.02%
	Rate of Adult Obesity	11.65%	12.12%
	Rate of Physical Inactivity		
Availability and Access to Health Care Services	Access to Primary Care Physicians (PCP)		
	Transportation	29.57%	
	Access to Mental Health Providers		17.48%
	Access to OB/GYN Providers		
	Rate of Uninsured Adults		
Social and Economic Environment	Rate of High School Graduation		15.22%
	Rate of Unemployment		
	Food Insecurity		
	Rate of Children in Single-Parent Households		
	Rate of Violent Crime	21.56%	14.35%
	Rate of Injury Deaths		
	Rate of Children in Poverty		
	Rate of Disconnected Youth		
	Availability of Social Associations		
Physical Environment	Air Pollution		
	Rate of Severe Housing Problems		
	Lead Exposure		

All-Cause 30-Day Readmissions

For All-Cause 30-Day Readmissions, adding SDOH variables increased the model's ability to accurately predict quality measure performance. However, none of the SDOH variables were found to have individually significant associations with All-Cause 30-Day Readmissions for STAR+PLUS adults, and only Air Pollution was significantly associated when stratified by the HCBS Waiver subpopulation (i.e., higher levels of air pollution were associated with increased readmissions). Still, the demographic variables, gender and age, were significantly associated with All-Cause 30-Day Readmissions, specifically STAR+PLUS men and older HCBS Waiver adults were more likely to have readmissions.

Interpretation: The lack of individual statistically significant associations should not be interpreted as SDOH not having any impacts on readmissions; rather, this result should be further evaluated. Plausible explanations for this finding could be that as a utilization-based quality measure, clinical factors might be highly relevant for this particular outcome; clinical characteristics were absent from this modelling and could be affecting the estimates for the SDOH analyses. Moreover, the smaller sample size for this quality measure affected the model's statistical power to significantly identify smaller effects, potentially missing nuanced associations between SDOH variables and the outcome.

Overall Composite Admissions Rate (Prevention Quality Indicator 90)

As shown in **Table 7**, only two SDOH variables, Rate of Severe Housing Problems (59.00%) and Rate of Violent Crime (41.00%), were significantly associated with Overall Composite Admission Rate (PQI 90) for STAR+PLUS adults, and when stratified by the HCBS Waiver subpopulation, only two SDOH variables had significant associations, Rate of Adult Smoking (68.09%) and Rate of Violent Crime (31.91%).

Interpretation: For STAR+PLUS adults and HCBS Waiver adults, increased rates of violent crime were associated with higher potentially preventable admissions. Among STAR+PLUS adults, severe housing problems were associated with higher potentially preventable admissions, and when stratified to HCBS Waiver adults, higher rates of adult smoking were associated with higher potentially preventable admissions. Although very few individual SDOH variables were significantly associated with this quality measure, these results should not be interpreted as all other SDOH not having any impacts on preventable admissions. With only 3% of the eligible STAR+PLUS population meeting the numerator criteria for analysis, i.e., had a qualifying admission, these results should be interpreted with caution since a smaller sample size affects the model's statistical power to significantly identify smaller, nuanced effects. Additionally, as a utilization-based quality measure, clinical factors might be highly relevant for this particular outcome, yet clinical characteristics were absent from this modelling and could be affecting the estimates for the SDOH analyses.

Table 7: Significant SDOH Variables on Overall Composite Admissions Rate (PQI 90)

SDOH Category	SDOH Variable	Percent Contribution to Collective SDOH Impact	
		STAR+PLUS	HCBS Waiver
Demographic Attributes	Race/Ethnicity		
Health Behaviors	Access to Exercise Opportunities		
	Rate of Sexually Transmitted Infections (STD)		
	Rate of Teen Births		
	Rate of Adult Smoking		68.09%
	Rate of Adult Obesity		
	Rate of Physical Inactivity		
Availability and Access to Health Care Services	Access to Primary Care Physicians (PCP)		
	Transportation		
	Access to Mental Health Providers		
	Access to OB/GYN Providers		
	Rate of Uninsured Adults		
Social and Economic Environment	Rate of High School Graduation		
	Rate of Unemployment		
	Food Insecurity		
	Rate of Children in Single-Parent Households		
	Rate of Violent Crime	41.00%	31.91%
	Rate of Injury Deaths		
	Rate of Children in Poverty		
	Rate of Disconnected Youth		
	Availability of Social Associations		
Physical Environment	Air Pollution		
	Rate of Severe Housing Problems	59.00%	
	Lead Exposure		

Identification of Alcohol and Other Drug (AOD) Services

Out of all the models for the quality measures for the HCBS Waiver subpopulation, the model for Identification of AOD Services had the highest percent concordance (68.9%), or degree of accuracy, in predicting the performance outcome 69% of the time. As shown in **Table 8**, nine SDOH variables were significantly associated with Identification of AOD Services for STAR+PLUS adults, and only one SDOH variable, Rate of Violent Crime, had a significant association when stratified by the HCBS Waiver subpopulation. The largest individual SDOH contributors on Identification of AOD Services for STAR+PLUS adults were Race/Ethnicity

(21.00%) and Access to OB/GYN Providers (15.21%). Based on the SDOH categories, the SDOH variables under the "Availability and Access to Health Care Services" category showed the largest categorical influence on quality measure performance for STAR+PLUS and HCBS Waiver adults.

Interpretation: For STAR+PLUS and HCBS Waiver adults, the SDOH variables under the category of "Availability and Access to Health Care Services" collectively contributed the most to receipt of AOD services (i.e., higher access to mental health, primary care, and even OB/GYN providers was associated with receipt of AOD services), which aligns with the quality measure's intent to measure treatment and services for alcohol and other chemical dependency issues. Among STAR+PLUS adults, White/Non-Hispanic individuals were less likely to be receiving appropriate services for alcohol and other chemical dependency compared to individuals of all other Race/Ethnicity groups (Hispanic, Black, American Indian/Alaskan, Pacific Islander/Asian, and "Unknown/Other"). This finding may align with literature that suggests racial and ethnic minority groups are at a higher risk of complications from alcohol and substance use disorders.[39] However, caution is advised when interpreting this result because the quality measure captures receipt of AOD services among all individuals (in this case all STAR+PLUS beneficiaries); the denominator is not limited to only those with alcohol and drug use disorders. Therefore, it cannot be determined whether the observed association is due to minority groups receiving more AOD services or due to fewer White/Non-Hispanic individuals having alcohol and drug use disorders to begin with compared to other racial/ethnic groups[40] (thus White/Non-Hispanic individuals being less likely to meet the numerator for this quality measure although meeting the denominator). When stratified to HCBS Waiver adults, higher rates of violent crime were associated with receipt of appropriate AOD services. Again, caution is required in interpreting this result since it may be that the observed association is due to counties with higher violent crime rates representing areas with more individuals with alcohol and drug use disorders to begin with. Lastly, a smaller sample size affects the model's power to significantly identify nuanced effects, potentially missing smaller but still significant associations between SDOH and this quality measure.

Table 8: Significant SDOH Variables on Identification of Alcohol and Other Drug (AOD) Services

SDOH Category	SDOH Variable	Percent Contribution to Collective SDOH Impact	
		STAR+PLUS	**HCBS Waiver**
Demographic Attributes	Race/Ethnicity	21.00%	
Health Behaviors	Access to Exercise Opportunities		
	Rate of Sexually Transmitted Infections (STD)		
	Rate of Teen Births	11.40%	
	Rate of Adult Smoking		
	Rate of Adult Obesity		
	Rate of Physical Inactivity	6.47%	
Availability and Access to Health Care Services	Access to Primary Care Physicians (PCP)	6.82%	
	Transportation		
	Access to Mental Health Providers	10.49%	
	Access to OB/GYN Providers	15.21%	
	Rate of Uninsured Adults		
Social and Economic Environment	Rate of High School Graduation		
	Rate of Unemployment		
	Food Insecurity		
	Rate of Children in Single-Parent Households		
	Rate of Violent Crime	6.89%	100%
	Rate of Injury Deaths	13.44%	
	Rate of Children in Poverty	8.29%	
	Rate of Disconnected Youth		
	Availability of Social Associations		
Physical Environment	Air Pollution		
	Rate of Severe Housing Problems		
	Lead Exposure		

Adults' Access to Preventive/Ambulatory Health Services

Out of all the models for the quality measures for the STAR+PLUS population, the model for Adults' Access to Preventive/Ambulatory Health Services had the highest percent concordance (68.50%), or degree of accuracy, in predicting the performance outcome almost 69% of the time. As shown in **Table 9**, eleven SDOH variables were significantly associated with Adults' Access to Preventive/Ambulatory Health Services for the STAR+PLUS population, and the largest individual SDOH contributors to Adults' Access to Preventive/Ambulatory Health Services were

Rate of Children in Poverty (24.62%), Availability of Social Associations (12.14%), and Food Insecurity (11.63%). Based on the SDOH categories, the SDOH variables under the "Social and Economic Environment" category showed the largest categorical influence on quality measure performance.

Interpretation: Among STAR+PLUS adults, greater availability of social associations and lower rates of disconnected youths were associated with receipt of preventive care services. Strong social support has been linked to better health outcomes among older people and those with disabilities[41,42], and this association in the STAR+PLUS population could reflect the importance of promoting social support networks within the STAR+PLUS population as a way to positively impact receipt of recommended preventive care. Additionally, higher access to primary care physicians was associated with receipt of preventive care services, which aligns with the quality measure's intent to measure access to ambulatory and preventive care visits. Conversely, higher rates food insecurity was associated with decreased access to preventive care services.

Table 9: Significant SDOH Variables on Adults' Access to Preventive/Ambulatory Health Services

SDOH Category	SDOH Variable	Percent Contribution to Collective SDOH Impact
Health Behaviors	Access to Exercise Opportunities	8.60%
	Rate of Sexually Transmitted Disease	5.12%
	Rate of Teen Births	5.71%
Availability and Access to Health Care Services	Access to Primary Care Physicians	6.17%
Social and Economic Environment	Rate of Unemployment	7.42%
	Food Insecurity	11.63%
	Rate of Violent Crime	3.59%
	Rate of Injury Deaths	8.93%
	Rate of Children in Poverty	24.62%
	Rate of Disconnected Youth	6.07%
	Availability of Social Associations	12.14%

Annual Monitoring for Patients on Persistent Medication

As shown in **Table 10**, seven SDOH variables were significantly associated with Annual Monitoring for Patients on Persistent Medication for the STAR+PLUS population, and the largest individual SDOH contributors to Annual Monitoring of Patients on Persistent Medication were Rate of Children in Single-Parent Households (27.17%), Rate of Injury Deaths (14.22%), and Rate

of Physical Inactivity (14.31%). Based on the SDOH categories, the SDOH variables under the "Social and Economic Environment" category showed the largest categorical influence on quality measure performance.

Interpretation: Among STAR+PLUS adults, lower rates of children in single-parent households, lower rates of food insecurity, and lower rates of injury deaths were associated with receiving appropriate monitoring for medication therapy. Conversely, higher rates of physical inactivity were associated with receiving appropriate treatment for medication therapy. This surprising association may actually be reflecting underlying clinical characteristics that are relevant to this quality measure, i.e., that individuals who are less physically active may also have other comorbidities that increase their likelihood to be appropriately monitored for their persistent medication.

Table 10: Significant SDOH Variables on Annual Monitoring for Patients on Persistent Medication

SDOH Category	SDOH Variable	Percent Contribution to Collective SDOH Impact
Health Behavior	Rate of Adult Obesity	7.46%
	Rate of Physical Inactivity	14.31%
Social and Economic Environment	Rate of High School Graduation	11.11%
	Food Insecurity	12.88%
	Rate of Children in Single-Parent Households	27.17%
	Rate of Injury Deaths	14.22%
Physical Environment	Air Pollution	12.86%

Comprehensive Diabetes Care: Eye Care

Out of all the quality measures assessed for the STAR+PLUS population, the largest number of significant associations were found for Comprehensive Diabetes Care: Eye Care. As shown in **Table 11**, sixteen SDOH variables were significantly associated with this quality measure for STAR+PLUS adults, and three SDOH variables, Access to Exercise Opportunities (42.20%), Rate of High School Graduation (33.41%), and Rate of Violent Crime (24.39%), had significant associations when stratified by the HCBS Waiver subpopulation. The largest individual SDOH contributors on Comprehensive Diabetes Care: Eye Exam for STAR+PLUS adults were Access to Exercise Opportunities (9.22%) and Food Insecurity (9.04%). Based on the SDOH categories, the SDOH variables under the "Social and Economic Environment" and "Availability

and Access to Health Care Services" categories showed the largest categorical influences on quality measure performance for STAR+PLUS and HCBS Waiver adults.

Interpretation: For the STAR+PLUS population, all of the SDOH variables under the category of "Availability and Access to Health Care Services" were positively associated with comprehensive diabetes care, which aligns with the quality measure's intent to measure recommended eye exams for individual with diabetes (i.e., higher access to mental health providers, primary care providers, even OB/GYN providers, and lower rates of uninsured adults were associated with individuals with diabetes more likely receiving recommended eye exams). Additionally, lower rates of food insecurity, transportation, adult smoking, disconnected youth, severe housing problems, and lead exposure were associated with STAR+PLUS adults with diabetes receiving recommended eye exams. It is important to note that the Transportation SDOH variable was an estimate of a person's miles traveled per day, not an estimate of a person's means for independent transportation. Thus, the observed association between transportation and increased inpatient admissions may actually be more reflective of the urbanity or rurality of an individual's environment, i.e., fewer miles traveled per day may reflect a more urban area with greater availability or access to specialty services, leading to increased diabetes eye exams. For STAR+PLUS and HCBS Waiver adults, better access to exercise opportunities and lower rates of violent crime were associated with receiving comprehensive diabetes care.

Table 11: Significant SDOH Variables on Comprehensive Diabetic Care: Eye Exam

SDOH Category	SDOH Variable	Percent Contribution to Collective SDOH Impact	
		STAR+PLUS	HCBS Waiver
Demographic Attributes	Race/Ethnicity		
Health Behaviors	Access to Exercise Opportunities	9.22%	42.20%
	Rate of Sexually Transmitted Infections (STD)	6.32%	
	Rate of Teen Births		
	Rate of Adult Smoking	7.96%	
	Rate of Adult Obesity	3.65%	
	Rate of Physical Inactivity		
Availability and Access to Health Care Services	Access to Primary Care Physicians (PCP)	4.93%	
	Transportation	7.80%	
	Access to Mental Health Providers	4.76%	
	Access to OB/GYN Providers	4.04%	

SDOH Category	SDOH Variable	Percent Contribution to Collective SDOH Impact	
		STAR+PLUS	HCBS Waiver
	Rate of Uninsured Adults	3.71%	
Social and Economic Environment	Rate of High School Graduation		33.41%
	Rate of Unemployment		
	Food Insecurity	9.04%	
	Rate of Children in Single-Parent Households		
	Rate of Violent Crime	5.37%	24.39%
	Rate of Injury Deaths		
	Rate of Children in Poverty	5.87%	
	Rate of Disconnected Youth	7.66%	
	Availability of Social Associations		
Physical Environment	Air Pollution	6.02%	
	Rate of Severe Housing Problems	7.43%	
	Lead Exposure	6.22%	

Breast Cancer Screening

Out of all the models for the quality measures for both the STAR+PLUS population and HCBS Waiver subpopulation, the model for Breast Cancer Screening had the largest percent concordance differential when SDOH variables were added, increasing in accuracy by up to 6.70-8.30 percentage points. As shown in **Table 12**, eleven SDOH variables were significantly associated with Breast Cancer Screening for STAR+PLUS adults, while five SDOH variables had significant associations when stratified by the HCBS Wavier subpopulation. The largest individual SDOH contributors on Breast Cancer Screening were Rate of Children in Poverty (22.06%) and Rate of Adult Obesity (12.75%) for STAR+PLUS adults and Rates of Single-Parent Households (22.39%) and Rate of High School Graduation (29.68%) for the HCBS Waiver subpopulation. Based on the SDOH categories, the SDOH variables under the "Social and Economic Environment" category showed the largest categorical influence on quality measure performance for STAR+PLUS adults and stratified HCBS Waiver adults.

Interpretation: For STAR+PLUS and HCBS Waiver adults, lower rates of adult obesity, lower rates of teen births, and higher rates of high school graduation were associated with higher rates of breast cancer screening. In the STAR+PLUS population, access to providers, including mental health, primary care, and OB/GYN providers, was positively associated with higher rates

of breast cancer screening, which aligns with the quality measure's intent to increase recommended screening for breast cancer in women 50-74 years of age.

Table 12: Significant SDOH Variables on Breast Cancer Screening

| SDOH Category | SDOH Variable | Percent Contribution to Collective SDOH Impact | |
		STAR+PLUS	HCBS Waiver
Demographic Attributes	Race/Ethnicity		
Health Behaviors	Access to Exercise Opportunities		
	Rate of Sexually Transmitted Infections (STD)	7.03%	
	Rate of Teen Births	10.64%	22.10%
	Rate of Adult Smoking		
	Rate of Adult Obesity	12.75%	11.68%
	Rate of Physical Inactivity		
Availability and Access to Health Care Services	Access to Primary Care Physicians (PCP)	10.07%	
	Transportation		
	Access to Mental Health Providers	5.21%	
	Access to OB/GYN Providers	6.37%	
	Rate of Uninsured Adults		15.14%
Social and Economic Environment	Rate of High School Graduation	8.08%	28.68%
	Rate of Unemployment	4.70%	
	Food Insecurity		
	Rate of Children in Single-Parent Households		22.39%
	Rate of Violent Crime	5.64%	
	Rate of Injury Deaths	7.47%	
	Rate of Children in Poverty	22.06%	
	Rate of Disconnected Youth		
	Availability of Social Associations		
Physical Environment	Air Pollution		
	Rate of Severe Housing Problems		
	Lead Exposure		

Follow-Up after Hospitalization for Mental Illness

As shown in **Table 13**, nine SDOH variables were significantly associated with Follow-Ip after Hospitalization for Mental Health Illness for the STAR+PLUS population, and the largest individual SDOH contributors to this quality measure were Rate of Children in Single-Parent Households (14.86%), Rate of Disconnected Youth (14.16%), and Rate of Children in Poverty

(13.51%). Based on the SDOH categories, the SDOH variables under the "Social and Economic Environment" category showed the largest categorical influence on quality measure performance.

Interpretation: Among STAR+PLUS adults, lower rates of children in single-parent households, disconnected youth, and children in poverty were associated with follow-up services provided for individuals after a hospitalization for mental illness. Surprisingly, access to mental health providers was not significantly associated, while access to OB/GYN providers and lower rates of transportation were significantly associated with this quality measure. It is important to note that the Transportation SDOH variable was an estimate of a person's miles traveled per day, not an estimate of a person's means for independent transportation. Thus, the observed association between transportation and follow-up services after hospitalization for mental illness may actually be more reflective of the urbanity or rurality of an individual's environment, i.e., fewer miles traveled per day may reflect a more urban area with greater availability or access to mental health services, leading to increased follow-up services. These findings may reflect the importance not only of having the availability of specialty providers but also of improving the coordination between inpatient and outpatient setting for the continuum of follow-up services needed for individuals with mental illness.

Table 13: Significant SDOH Variables on Follow-Up After Hospitalization for Mental Illness

SDOH Category	SDOH Variable	Percent Contribution to Collective SDOH Impact
Health Behaviors	Rate of Sexually Transmitted Infections (STD)	10.56%
	Rate of Physical Inactivity	7.25%
Availability and Access to Health Care Services	Transportation	10.59%
	Access to OB/GYN Providers	7.94%
Social and Economic Environment	Rate of Children in Single-Parent Households	14.86%
	Rate of Children in Poverty	13.51%
	Rate of Disconnected Youth	14.16%
Physical Environment	Air Pollution	11.79%
	Rate of Severe Housing Problems	9.35%

Use of Opioids from Multiple Providers

As shown in **Table 14**, eleven SDOH variables were significantly associated with Use of Opioids from Multiple Providers for STAR+PLUS adults, while only two SDOH variables had

significant associations when stratified by the HCBS Waiver subpopulation. The largest individual SDOH contributors on Use of Opioids from Multiple Providers for STAR+PLUS adults were Race/Ethnicity (16.04%), Food Insecurity (12.24%), Rate of Children in Poverty (9.55%), and Access to Mental Health Provider (9.04%). Although very few of the stratified results for the HCBS Waiver subpopulation were significant, the stratified results should be interpreted with caution since a smaller sample size affects the model's power to significantly identify smaller, nuanced effects. However, the two SDOH variables with significant associations in the HCBS Waiver subpopulation were also significant in the STAR+PLUS population, suggesting Rate of Adult Obesity and Rate of Physical Inactivity are associated to some extent with this quality measure. Based on the SDOH categories, the SDOH variables under the "Social and Economic Environment" category showed the largest categorical influence on quality measure performance for STAR+PLUS adults and stratified HCBS Waiver adults.

Interpretation: Among STAR+PLUS adults, White/Non-Hispanic individuals were less likely to be prescribed opioids by multiple providers (four or more providers) compared to all other Race/Ethnicity groups. Additionally, higher food insecurity, higher rates of children in poverty, higher access to mental health providers, higher access to OB/GYN providers, and lower access to primary care providers were associated with STAR+PLUS adults receiving opioid prescriptions by multiple providers. This quality measure serves as an indicator of harmful prescribing practices that have been shown to increase the risk of overdose and death due to overdose among patients.[42-43]

Table 14: Significant SDOH Variables on Use of Opioids from Multiple Prescribers

SDOH Category	SDOH Variable	Percent Contribution to Collective SDOH Impact	
		STAR+PLUS	HCBS Waiver
Demographic Attributes	Race/Ethnicity	16.04%	
Health Behaviors	Access to Exercise Opportunities		
	Rate of Sexually Transmitted Infections (STD)		
	Rate of Teen Births		
	Rate of Adult Smoking		
	Rate of Adult Obesity	6.23%	41.76%
	Rate of Physical Inactivity	8.93%	58.24%
	Access to Primary Care Physicians (PCP)	8.26%	

SDOH Category	SDOH Variable	Percent Contribution to Collective SDOH Impact	
		STAR+PLUS	HCBS Waiver
Availability and Access to Health Care Services	Transportation		
	Access to Mental Health Providers	9.04%	
	Access to OB/GYN Providers	5.80%	
	Rate of Uninsured Adults	9.17%	
Social and Economic Environment	Rate of High School Graduation	8.03%	
	Rate of Unemployment		
	Food Insecurity	12.24%	
	Rate of Children in Single-Parent Households		
	Rate of Violent Crime	6.70%	
	Rate of Injury Deaths		
	Rate of Children in Poverty	9.55%	
	Rate of Disconnected Youth		
	Availability of Social Associations		
Physical Environment	Air Pollution		
	Rate of Severe Housing Problems		
	Lead Exposure		

DISCUSSION AND STUDY LIMITATIONS

This addendum supported the findings from the study on Medicaid children, adolescent, and pregnant women populations that a model including SDOH variables was more accurate in predicting whether an individual would meet the numerator performance criteria of a quality measure than a model without SDOH variables. This finding was consistent for the STAR+PLUS population and when stratified by the HCBS Waiver subpopulation. In other words, the addendum's overall finding suggested that the social context in which STAR+PLUS and HCBS Waiver members lived, as represented by the set of SDOH variables included in this addendum, was important to better understanding performance outcomes on key health care quality metrics, such as NCQA HEDIS® and AHRQ PQI measures.

Similar to the study, this addendum also found that the number of individual SDOH variables with significant associations varied by quality measure, highlighting that although the social context was an important overall consideration, not every SDOH variable contributed equally to the observed impact of SDOH on quality measure performance in the STAR+PLUS population and the HCBS Waiver subpopulation. For example, while there was not one unique SDOH variable significantly associated with all quality measures for the STAR+PLUS population

and HCBS Waiver subpopulation, Rate of Violent Crime was significantly associated with the largest number of quality measures (eight of the eleven STAR+PLUS quality measures and five of the eight HCBS Waiver quality measures). Still, the relative influence of violent crime varied per quality measure. This finding indicated that further research would be needed to better understand if a single unique SDOH variable may be the most influential on all performance outcomes for a given Medicaid population. Alternatively, this finding may suggest that identifying a single influential SDOH variable is less important than understanding that there are significant associations between SDOH variables and quality measures for Medicaid populations.

Moreover, grouping the SDOH variables into five categories: 1) "Demographic Attributes" (Race/Ethnicity), 2) "Health Behaviors", 3) "Availability and Access to Health Care Services", 4) "Social and Economic Environment", and 5) "Physical Environment" provided another lens in which to interpret the overall findings as well as assess any potentially interrelated SDOH variables. Based on the categorization of SDOH variables, "Social and Economic Environment" showed the largest categorical influence on quality measure performance for most models in this addendum, which was similarly found in the study. However, it should be noted that this SDOH category contained the largest number of individual SDOH variables within its grouping, which could reflect that this SDOH category had more available data to evaluate SDOH impacts to begin with. Still, this limitation should not diminish the categorical influence and relevance of "Social and Economic Environment" but rather suggest caution in establishing and denoting higher importance of one SDOH category over another SDOH category.

In contrast to results from the study, Race/Ethnicity was less commonly significant for the STAR+PLUS population and HCBS Waiver subpopulation than for the children, adolescent, and pregnant women populations. Among STAR+PLUS adults, Race/Ethnicity was significantly associated with only three out of the eleven quality measures, ED Utilization, Identification of AOD Services, and Use of Opioids from Multiple Providers, finding that White/ Non-Hispanic individuals were less likely to have an ED visit, receive appropriate AOD services, and be prescribed opioids by four or more providers. Additionally, unlike the results in the study, this addendum found that the demographic variables, age and gender, were significant contributors to observed associations for some quality measures. This finding may reflect the intensity of aging as a risk factor, especially on the health status of individuals already at higher risk, such as adults in the STAR+PLUS population and HCBS Waiver subpopulation.

Furthermore, in this addendum, many of the quality measures assessed for the STAR+PLUS population involved inverse performance directionality, making the interpretation of each significant association more complex in that the directionality of some of the associations were unexpected. For example, as mentioned, Rate of Violent Crime was significantly associated with the most quality measures for the STAR+PLUS population and HCBS Waiver subpopulation, highlighting the significant role that violent crime plays on performance outcomes for Medicaid adults; however, the directionality of the associations per quality measure were not always expected and presented challenges in interpretation. Higher rates of violent crime were associated with higher Acute Inpatient Utilization and Overall Composite Admission (PQI 90), and lower rates of violent crime were associated with higher performance in Breast Cancer Screening, Comprehensive Diabetes Care: Eye Exam, and Identification of Alcohol and other Drug related Services. However, lower rates of violent crime were also associated with increased Use of Opioids from Multiple Prescribers and Emergency Department Visits, which reflects associations with unexpected performance directionality. Violent Crimes could cover events as dissimilar as inter partner violence as well as being the result of over-policing in particular counties. Moreover, due to this variable being used at county level, the true exposure to violent crime rates of an individual could be missed if there is considerable within county variation, as it often occurs in urban areas. Therefore, though this result highlights the importance of better understanding factors or conditions related to violent crime and safety, it is important to exercise caution when extrapolating this result into further interpretation. Where the directionality of significant associations was unexpected, findings need to be interpreted with caution, given the multiple and complex types of factors captured through the set of SDOH variables.

When interpreting the results of this addendum, similar limitations apply to this addendum as to the study since the methodological approach was identical. First, the individual must be assigned to a social "community". However, given the variety of available SDOH data sources for this study, the "community" was defined as the individual's county of residence, which may not have reflected the social context of the individual Medicaid member and may have masked differences within a county and any individual exposures.

Second, the assigned value of a SDOH variable to the county may not have been representative of the subjects in the study. For example, this addendum used Rate of Uninsured Adults as one of the SDOH variables assessed. Yet, since none of the subjects were uninsured (i.e.,

all subjects were Medicaid members), this SDOH variable only reflected the rate of uninsured adults in the community where the subject lived. Although the characteristics of the neighborhood where individuals live are acknowledged risk factors for health outcomes,[33,34,37] using broad geographic-level risk factors to indirectly assess specific individual-level risk factors may have reduced the ability to capture an accurate effect.

Third, SDOH variables may have been strongly interrelated among themselves. This study attempted to control for such confounding by proactively identifying highly correlated SDOH variables and, when appropriate, consolidating correlated SDOH variables into a single representative SDOH variable (e.g., Food Insecurity). However, other interrelationships may have existed across the SDOH variables that the analysis may not have been able to appropriately control, or an individual SDOH variable may have acted as a proxy for another factor that may not have been captured or accurately in this addendum. Moreover, particularly relevant for the stratified analyses of the HCBS Waiver subpopulation, the overall smaller sample sizes decreased the models' statistical power to significantly identify smaller, nuanced effects.

Fourth, for most models across both the STAR+PLUS population and HCBS Waiver subpopulation, the resulting C-values were slightly above the random effects point (0.50). The relatively small overall C-values should not be discouraging because it might imply that there were other variables missing from the modeling, and this finding should not be discouraging because it might imply that there were other variables missing from the modeling. For example, other influencing variables may have included underlying clinical risk factors, caregiver-related factors, the MCO-related factors (health plan design and additional benefits), and provider-related factors (type of organizations and services).

Finally, as a cross-sectional study design, while the results indicated that there were significant associations between individual SDOH variables and the performance outcomes of quality measures, the results could not be interpreted as direct causal relationships.

Given these limitations, several recommendations could be considered by policy makers, Medicaid MCOs, and providers that align across Medicaid managed care populations and specifically address the STAR+PLUS population. First, across Medicaid managed care populations, access to member-level SDOH data could further improve the accuracy of statistical modeling, help identify which individual SDOH variables are significantly associated with quality measure performance at the member level, and supplement valuable information for clinical care

planning. To encourage member-level assignment of SDOH values, a set of standardized SDOH variables could be defined and member-level SDOH data could be collected during Medicaid and CHIP enrollment or by the MCOs or providers. Since there are a variety of collection points for such SDOH data, including upon enrollment, during a clinic visit, during case management, and using member surveys, the approach to SDOH data collection should be systematic and standardized where possible.

Second, building mutual engagement and buy-in among policy makers, providers, and MCOs regarding the impact of SDOH on quality measure performance is important. Providers and their care teams could be the key players for screening and documenting member-level SDOH data in the medical record and MCOs could be the key players for capturing and analyzing such SDOH data within the claims data; regardless, engagement and buy-in should be collaborative since there is value in both medical records which capture clinical progress and claims data which captures health care service utilization. In fact, diagnostic Z codes (ICD-10-CM codes in categories Z55-Z56)[41] already exist that define SDOH and other non-medical factors that may influence a patient's health status or health behaviors, including education and literacy, employment, housing, lack of adequate food or water, or exposure to physical or community risk factors. However, unless provider and MCO engagement and buy-in to use Z codes is high, this avenue for member-level SDOH data collection may not succeed.

Lastly, building off this addendum's findings, another recommendation would be to further explore the impact of SDOH on quality measure performance by strategically targeting fewer SDOH variables based on the largest SDOH categorical influence (e.g., the SDOH variables within the "Social and Economic Environment" category) or largest degree of individual SDOH variable influence (e.g., Rate of Violent Crime which was a significant SDOH variable across most measures for both the STAR+PLUS and the HCBS Waiver subpopulation. A targeted approach could inform how policy makers, providers, and MCOs prioritize interventions and strategies addressing SDOH for Medicaid members. For example, Rate of Adult Smoking was significantly associated with higher ED utilization among STAR+PLUS adults, higher preventable hospitalization among HCBS Waiver adults, and higher acute inpatient admissions for both STAR+PLUS and HCBS Waiver adults, a possible strategy could focus on designing and developing population-specific smoking cessation interventions, campaigns, and peer support groups.

As policy makers, MCOs, and providers look to better understand the impact of SDOH on Medicaid health outcomes, this addendum provided important findings supporting the relevance of SDOH variables collectively and individually on key measures of health care quality for the STAR+PLUS population and HCBS Waiver subpopulation. By expanding upon the study, this addendum comprehensively supports the development of a statewide approach for continuously improving the quality of health care delivered to all Medicaid beneficiaries, including children, adolescents, pregnant women, and adults in Texas Medicaid.

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Appendix I: Social Determinants of Health (SDOH) Variables Data

SDOH Variable	Data Source	Description of the SDOH Variable
Demographic Attributes		
Race/Ethnicity	Enrollment Data	White/Non-Hispanic as the reference group compared to Hispanic, Black, American Indian/Alaskan, Pacific Islander/Asian and unknown/other. Used as a SDOH variable.
Gender	Enrollment Data	Binary variable (Male/Female). Male used as reference. Used in all models.
Age	Enrollment Data	Continuous variable. Used in all models
Health Behaviors		
Access to Exercise Opportunities	Business Analyst, Delorme map data, ESRI, & US Census Tiger line Files	Three sources are combined to create the measure that rates the access to exercise opportunities through the identification of parks, community centers, gyms, walking trails, etc.
Rate of Sexually Transmitted Disease (STD)	National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention	This dataset reports the rate of chlamydia, a sexually transmitted disease (STD).
Rate of Teen Births	National Center for Health Statistics - Natality Files	This reports the rate of teen births, as derived from vital records.
Rate of Adult Smoking	Behavioral Risk Factor Surveillance System	This reports the rate of smoking among adults, as derived from self-reported data.
Rate of Adult Obesity	United States Diabetes Surveillance System	This reports the rate of adult obesity from self-reported data on height, weight, and BMI.
Rate of Physical Inactivity	United States Diabetes Surveillance System	This is a rate of adult physical inactivity derived from self-reported data on hours engaged in physical activity per week.
Availability and Access to Health Care Services		
Access to Primary Care Physicians	Area Health Resource File/American Medical Association	The rate of primary care physicians per population is used to define access.
Transportation	Local Area Transportation Characteristics for Households (LATCH Survey)	This data is an estimate of a person's miles traveled, per day.
Access to Mental Health Providers	CMS, National Provider Identification	The rate of mental health providers per population is used to define access.
Access to OB/GYN Providers	Mapping Medicare Disparities Tool	The availability of obstetricians and gynecologists per population is used to define access.
Rate of Uninsured Adults	Small Area Health Insurance Estimates	The estimates of health insurance coverage are used to derive estimates on the number of people without health insurance.

SDOH Variable	Data Source	Description of the SDOH Variable
Social and Economic Environment		
Rate of High School Graduation	ED Facts	The rate of children who graduate high school.
Rate of Unemployment	Bureau of Labor Statistics	The rate of unemployment among adults.
Food Insecurity	Map the Meal Gap	The percentage of population who lack adequate access to food for an active, healthy life for all household members and limited or uncertain availability of nutritionally adequate foods.
Rate of Children in Single-Parent Households	American Community Survey, 5-Year Estimates	The rate of single parent households with children.
Rate of Violent Crime	Uniform Crime Reporting – FBI	Data provided by nearly 17,000 law enforcement agencies across the United States are used to report the rate of violent crime. Violent crime classification includes rape or sexual assault, robbery, aggravated assault, simple assault, domestic violence and violent crime involving injury.
Rate of Injury Deaths	National Center for Health Statistics - Mortality Files	The rate of deaths that are a result of injury.
Rate of Children in Poverty	Small Area Income and Poverty Estimates	The rate of children who live in families with income below the poverty threshold (100% of the Federal Poverty Guideline).
Rate of Disconnected Youth	The American Community Survey (ACS)	The percentage of teens and young adults ages 16-19 who are neither working nor in school.
Availability of Social Associations	County Business Patterns	The total number of membership associations in a county. The associations include membership organizations such as civic organizations, fitness centers, sports venues, sports organizations, churches and religious organizations, political organizations, labor organizations, business organizations, and professional organizations.
Physical Environment		
Air Pollution	Environmental Public Health Tracking Network	An assessment of air pollution created by monitoring and modeling the exposure to ozone and fine particles between 0.1 micrometers and 2.5 micrometers (PM 2.5)
Rate of Severe Housing Problems	Comprehensive Housing Affordability Strategy (CHAS) data	The extent of households with housing problems and household income low enough

SDOH Variable	Data Source	Description of the SDOH Variable
		to qualify for housing assistance as reported by CHAS.
Lead Exposure	Texas Department of Health and Human Services	Data from the surveillance system of blood lead test results for children.

Appendix II: Quality Measures Data

Quality Measure	Data Source	Description of the Quality Measure
Member ID	Enrollment file	Medicaid member ID or unique dummy ID
AMB: Emergency Department Visits All Ages Services/1000MM.	Quality Indicator EQRO file; HEDIS®	This measure summarizes utilization of ambulatory care in the following categories: ED visits. Numerator criteria include members with an ED visit.
IPU: Inpatient Utilization – General Hospital/Acute Care.	Quality Indicator EQRO file; HEDIS®	This measure summarizes utilization of acute inpatient care services in the following categories: total inpatient, maternity, surgery, and medicine. Numerator criteria includes members with an inpatient stay.
PCR: Plan All-Cause Readmissions.	Quality Indicator EQRO file; HEDIS®	For members 18 years of age and older, the number of acute inpatient stays during the measurement year that were followed by an unplanned acute readmission for any diagnosis within 30 days and the predicted probability of an acute readmission. Data are reported in the following categories: 1. Count of Index Hospital Stays (HIS) (denominator). 2. Count of 30-Day Readmissions (numerator). 3. Expected Readmissions Rate. Note: For commercial and Medicaid, report only members 18-64 years of age. Numerator criteria include members with a 30-day all cause readmission.
PQI90: Prevention Quality Overall Composite – Total/100,000MM.	Quality Indicator EQRO file; AHRQ	Prevention Quality Indicators (PQI) overall composite per 100,000-member months, ages 18 years and older. Includes admissions for one of the following conditions: diabetes with short-term complications, diabetes with long-term complications, uncontrolled diabetes without complications, diabetes with lower-extremity amputation, chronic obstructive pulmonary disease, asthma, hypertension, heart failure, bacterial pneumonia, or urinary tract infection. Numerator criteria include members with admission that follow the measure's criteria.
AAP: Adults' Access to Preventive/Ambulatory Health Services.	Quality Indicator EQRO file; HEDIS®	The percentage of members 20 years and older who had an ambulatory or preventive care visit during the measurement year. The numerator

Quality Measure	Data Source	Description of the Quality Measure
		criteria include members with an ambulatory/prevention visit.
IAD: Identification of Alcohol and Other Drug Services.	Quality Indicator EQRO file; HEDIS®	This measure summarizes the number and percentage of members with an alcohol and other drug (AOD) claim who received the following chemical dependency services during the measurement year: inpatient, intensive outpatient or partial hospitalization, outpatient or an ambulatory Medication Assisted Treatment (MAT) dispensing event, Emergency Department (ED), telehealth, and any service. Numerator criteria include members with an alcohol or other drug claim as specified by measure.
MPM: Annual Monitoring for Patients on Persistent Medications.	Quality Indicator EQRO file; HEDIS®	The percentage of members 18 years and older who received at least 180 treatment days of ambulatory medication therapy for a select therapeutic agent during the measurement year and at least one therapeutic monitoring event for the therapeutic agent in the measurement year. For each product line, report each of the three rates separately and as a total rate: annual monitoring for members on angiotens in converting enzyme (ACE) inhibitors or angiotens in receptor blockers (ARB), annual monitoring for members on digoxin, annual monitoring for members on diuretics, and total rate (the sum of the three numerators divided by the sum of the three denominators). Numerator criteria include members with an annual monitoring service.
CDC: Comprehensive Diabetes Care, Eye Exam	Quality Indicator EQRO file; HEDIS®	The percentage of members 18-75 years of age with diabetes (type 1 and type 2) who had each the following: eye exam (retinal) performed. Numerator criteria include members who had an eye exam.
BCS: Breast Cancer Screening.	Quality Indicator EQRO file; HEDIS®	The percentage of women 50-74 years of age who had a mammogram to screen for breast cancer in the last two years. Numerator criteria include members with Breast Cancer Screening.
FUH: Follow-Up After Hospitalization for Mental Illness.	Quality Indicator EQRO file; HEDIS®	The percentage of discharges for members 6 years of age and older who were hospitalized for treatment of selected mental illness diagnoses and who had a follow-up visit with a mental health practitioner. Two rates are reported:

Quality Measure	Data Source	Description of the Quality Measure
		1. The percentage of discharges for which the member received follow-up within 30 days of discharge. 2. The percentage of discharges for which the member received follow-up within 7 days of discharge. Numerator criteria include members who had a 30 day follow up visit.
Use of Opioids from Multiple Providers	Quality Indicator EQRO file; HEDIS®	The percentage of members 18 years and older, receiving prescription opioids for at least 15days during the measurement year who received opioids from multiple providers. Three rates are reported: 1. Multiple: The percentage of members receiving prescriptions for opioids from four or more different prescribers during the measurement year. 2. Multiple Pharmacies: The percentage of members receiving prescriptions for opioids from four or more different pharmacies during the measurement year. 3. Multiple Prescribers and Multiple Pharmacies: The percentage of members receiving prescriptions for opioids from four or more different prescribers and four or more different pharmacies during the measurement year (i.e., the percentage of members who are numerator compliant for both the Multiple Prescribers and Multiple Pharmacies rates). Note: A lower rate indicates better performance for all three rates. Numerator criteria include members who used opioids prescribed by four or more different providers.

Appendix III: Detailed Results STAR+PLUS Models

Variables	Adults' Access to Preventive/Ambulatory Health Services	Emergency Department (ED) Utilization	Breast Cancer Screening	Comprehensive Diabetes Care: Eye Care	Follow-Up after Hospitalization for Mental Illness	Identification of Alcohol and Other Drug (AOD) Services	Acute Inpatient Utilization	Annual Monitoring for Patients on Persistent Medication	All-Cause 30-Day Readmissions	Overall Composite Admissions Rate (PQI 90)	Use of Opioids from Multiple Providers
Age	0.034*	0.007*	0.010*	0.023*	-0.012*	0.028*	0.026*	0.024*	-0.001	0.043*	-0.017*
Gender	0.332*	0.228*	--	0.125*	0.091*	-0.397*	0.073*	0.135*	-0.083*	0.047*	0.115*
Race/Ethnicity	-0.029	0.088*	0.051	0.012	-0.229	0.162*	0.067	-0.166	0.043	0.116	0.202*
Access to Exercise Opportunities	-0.082*	0.010	-0.011	-0.124*	-0.038	0.038	0.013	-0.061	0.050	0.053	-0.035
Rate of Sexually Transmitted Disease (STD)	-0.049*	-0.062*	-0.066*	-0.085*	-0.185*	-0.036	0.015	-0.058	0.005	0.021	0.003
Rate of Teen Births	-0.054*	0.037*	-0.099*	0.008	0.035	-0.087*	-0.044*	0.056	-0.016	0.022	0.043
Rate of Adult Smoking	0.016	0.025*	-0.042	0.107*	0.077	0.039	0.027	0.060	-0.016	0.051	-0.051
Rate of Adult Obesity	-0.007	0.039*	0.119*	0.049*	-0.027	0.006	-0.022*	-0.058*	-0.028	-0.013	0.079*
Rate of Physical Inactivity	0.002	0.005	-0.032	-0.004	-0.123*	-0.052*	0.016	0.111*	-0.054	0.004	-0.113*
Access to Primary Care Physicians	0.059*	0.016	0.094*	0.066*	-0.137	-0.055*	0.028	0.056	0.027	-0.005	-0.104*
Access to Mental Health Providers	0.001	0.043*	0.049*	0.064*	-0.045	0.085*	0.014	0.050	-0.004	0.005	0.114*
Transportation	0.026	-0.001	0.011	-0.105*	-0.187*	0.009	0.058*	-0.024	0.041	0.049	0.010
Access to OB/GYN Providers	-0.014	-0.020*	0.059*	0.054*	0.145*	0.122*	0.000	-0.006	-0.029	0.022	0.073*
Rate of Uninsured Adults	0.002	-0.019	0.004	0.050*	0.029	0.003	0.024	0.076	0.013	0.038	-0.116*

Variables	Adults' Access to Preventive/Ambulatory Health Services	Emergency Department (ED) Utilization	Breast Cancer Screening	Comprehensive Diabetes Care: Eye Care	Follow-Up after Hospitalization for Mental Illness	Identification of Alcohol and Other Drug (AOD) Services	Acute Inpatient Utilization	Annual Monitoring for Patients on Persistent Medication	All-Cause 30-Day Readmissions	Overall Composite Admissions Rate (PQI 90)	Use of Opioids from Multiple Providers
Rate of High School Graduation	-0.002	-0.035*	-0.075*	-0.005	0.030	-0.032	-0.001	-0.086*	-0.046	0.003	-0.101*
Rate of Unemployment	0.071*	-0.026*	0.044*	-0.022	-0.062	0.002	0.013	0.002	0.004	-0.003	-0.004
Food Insecurity	-0.111*	0.034*	-0.035	-0.121*	0.089	-0.045	-0.016	-0.100*	0.063	0.016	0.155*
Rate of Children in Single-Parent Households	-0.025	0.070*	-0.072	0.012	-0.263*	0.031	0.036	-0.211*	0.029	-0.013	0.039
Rate of Violent Crime	0.034*	-0.039*	-0.053*	-0.072*	-0.005	-0.057*	0.041*	0.013	0.048	0.054*	-0.084*
Rate of Injury Deaths	-0.085*	0.064*	0.070*	-0.040	-0.008	0.110*	-0.001	-0.111*	-0.023	-0.017	0.018
Rate of Children in Poverty	0.234*	-0.072*	0.206*	0.079*	0.239*	0.060	-0.005	0.079	0.001	-0.069	-0.121*
Rate of Disconnected Youth	-0.058*	0.005	-0.053	-0.103*	-0.242*	-0.008	0.000	-0.070	-0.016	0.014	-0.009
Availability of Social Associations	0.116*	0.082*	-0.031	0.015	-0.026	0.039	-0.025	-0.097	-0.125	-0.042	-0.052
Air Pollution	-0.004	0.049*	0.048	0.081*	0.202*	0.035	0.008	0.100*	-0.016	0.022	-0.016
Rate of Severe Housing Problems	-0.033	0.044*	0.022	-0.100*	-0.164*	0.002	-0.023	-0.048	-0.037	-0.070*	0.019
Lead Exposure	-0.020	0.007	-0.028	-0.084*	-0.168	0.057	0.008	0.014	0.021	0.004	0.070

Note: * indicates a coefficient with a p-value equal to or less than 0.05. Male was used as the reference group for the Gender variable, and White/Non-Hispanic was used as the reference group for the Race/Ethnicity variable.

Appendix IV: STAR+PLUS Population and HCBS Waiver Subpopulation Frequency and Rates

Quality Measures	N	HCBS Enrollment for 6 mos or more during 2018		Met Requirement or Quality Indicator		%	Chi Square	P-Value
Adults' Access to Preventive/ Ambulatory Health Services	198,846	Yes	15,670	Yes	15,235	97.2%	2,056.29	<.0001
				No	435	2.8%		
		No	183,176	Yes	153,211	83.6%		
				No	29,965	16.4%		
Emergency Department (ED) Utilization	264,890	Yes	17,411	Yes	9,316	53.5%	1,148.80	<.0001
				No	8,095	46.5%		
		No	247,479	Yes	100,037	40.4%		
				No	147,442	59.6%		
Breast Cancer Screening	36,910	Yes	4,382	Yes	2,359	53.8%	17.74	<.0001
				No	2,023	46.2%		
		No	32,528	Yes	16,409	50.4%		
				No	16,119	49.6%		
Comprehensive Diabetes Care: Eye Care	49,009	Yes	6,658	Yes	3,770	56.6%	133.92	<.0001
				No	2,888	43.4%		
		No	42,351	Yes	20,750	49.0%		
				No	21,601	51.0%		
Follow-Up after Hospitalization for Mental Illness	8,372	Yes	607	Yes	326	53.7%	20.35	<.0001
				No	281	46.3%		
		No	7,765	Yes	3,436	44.2%		
				No	4,329	55.8%		
Identification of Alcohol and Other Drug (AOD) Services	264,890	Yes	17,411	Yes	992	5.7%	16.44	<.0001
				No	16,419	94.3%		
		No	247,479	Yes	12,378	5.0%		
				No	235,101	95.0%		
Acute Inpatient Utilization	264,890	Yes	17,411	Yes	4,637	26.6%	2,681.09	<.0001
				No	12,774	73.4%		
		No	247,479	Yes	31,446	12.7%		
				No	216,033	87.3%		
Annual Monitoring for Patients on Persistent Medication	51,811	Yes	6,327	Yes	6,063	95.8%	76.42	<.0001
				No	264	4.2%		
		No	45,484	Yes	42,247	92.9%		
				No	3,237	7.1%		
All-Cause 30-Day Readmissions	29,960	Yes	4,358	Yes	1,029	23.6%	39.48	<.0001
				No	3,329	76.4%		
		No	25,602	Yes	4,989	19.5%		
				No	20,613	80.5%		
Overall Composite Admissions Rate (PQI 90)	264,890	Yes	17,411	Yes	1,316	7.6%	1,162.88	<.0001
				No	16,095	92.4%		

Quality Measures	N	HCBS Enrollment for 6 mos or more during 2018		Met Requirement or Quality Indicator		%	Chi Square	P-Value
		No	247,479	Yes	7,100	2.9%		
				No	240,379	97.1%		
Use of Opioids from Multiple Providers	44,377	Yes	5,882	Yes	1,241	21.1%	40.42	<.0001
				No	4,641	78.9%		
		No	38,495	Yes	6,802	17.7%		
				No	31,693	82.3%		
Total	264,890	Yes	17411					
		No	247479					

Appendix V: Detailed Results STAR+PLUS HCBS Models

Variables	Emergency Department (ED) Utilization	Breast Cancer Screening	Comprehensive Diabetes Care: Eye Care	Identification of Alcohol and Other Drug (AOD) Services	Acute Inpatient Utilization	All – Cause 30-Day Readmissions	Overall Composite Admissions Rate (PQI 90)	Use of Opioids from Multiple Providers
Age	0.0190*	-0.0044	0.0257*	0.0410*	0.0183*	0.0112*	0.0322*	-0.0067*
Gender	0.1634*		0.0764*	-0.4146*	-0.0038	-0.0679	0.0130	0.1119*
Race/ Ethnicity	-1.7972	0.0743	0.1508	0.0464	0.1109	1.5755	1.6636	1.9835
Access to Exercise Opportunities	0.0219	0.0385	-0.1740*	-0.0333	0.0518	0.0584	0.1434	-0.0585
Rate of Sexually Transmitted Disease (STD)	-0.1067*	0.0629	0.0032	-0.0354	0.1055*	-0.1452	-0.0401	-0.0008
Rate of Teen Births	-0.0006	-0.2337*	0.0685	-0.0238	-0.1006	0.0771	-0.0184	0.1060
Rate of Adult Smoking	0.0318	0.1088	0.0742	-0.0364	0.1235*	0.1140	0.2324*	-0.0818
Rate of Adult Obesity	0.0486*	0.1236*	-0.0108	0.0897	-0.0680*	-0.0974	-0.0487	0.0971*
Rate of Physical Inactivity	-0.0678*	0.0194	0.0730	-0.0418	-0.0218	0.0914	-0.0084	-0.1355*
Access to Primary Care Physicians	0.0433	0.0938	0.1217	0.0260	0.0229	0.0043	0.0022	-0.0606
Access to Mental Health Providers	-0.0319	0.0693	0.0790	0.1185	-0.0980*	0.0079	-0.1214	0.0379
Transportation	-0.0183	0.0023	-0.1193	-0.1118	0.0336	-0.0545	-0.0265	0.0223
Access to OB/GYN Providers	-0.0064	0.1101	-0.0617	0.0886	0.0257	-0.1021	0.0153	0.0793
Rate of Uninsured Adults	0.0216	0.1601*	-0.0223	0.0701	0.0532	-0.0460	0.0726	-0.0736
Rate of High School Graduation	-0.1380*	-0.3033*	-0.1378*	-0.0865	0.0854*	-0.1227	0.0234	-0.0113
Rate of Unemployment	-0.0086	0.1112	-0.0772	0.0486	0.0090	0.0721	0.0117	-0.0927
Food Insecurity	0.0627	-0.0849	-0.0442	-0.0054	-0.0307	-0.1473	-0.1153	0.1659*
Rate of Children in Single-Parent Households	0.0883	-0.2368*	-0.0540	0.0120	0.0650	-0.0056	0.0970	0.1101
Rate of Violent Crime	-0.0617*	-0.0805	-0.1006*	-0.1718*	0.0804*	0.0440	0.1089*	-0.0679
Rate of Injury Deaths	0.1129*	0.1518	-0.1170	0.0569	-0.0188	-0.1315	-0.0232	0.0692

Rate of Children in Poverty	-0.1089*	0.0283	0.1107	-0.0518	-0.0317	-0.0951	-0.1497	-0.1513
Rate of Disconnected Youth	-0.0458	0.0685	-0.0786	0.0126	-0.0632	-0.1977	-0.1272	-0.0433
Availability of Social Associations	0.1763*	-0.1155	-0.1177	0.0108	0.1621	0.3868	0.1812	-0.2452
Air Pollution	-0.0048	0.0252	0.0372	0.0050	0.0418	0.2397*	0.1231	-0.0739
Rate of Severe Housing Problems	0.0044	-0.0409	-0.0778	-0.0012	-0.0586	0.0290	-0.1174	0.0096
Lead Exposure	0.0782	0.0288	0.0218	0.0764	-0.0711	0.0281	-0.0594	0.0931

Note: * indicates a coefficient with a p-value equal to or less than 0.05. Male was used as the reference group for the Gender variable, and White/Non-Hispanic was used as the reference group for the Race/Ethnicity variable.