Supplemental Information

Supplemental Information File 1: Detailed Description of Measures

Measures

Exposure

Socioeconomic position (0–1 year). Family socioeconomic position was based on an existing measure,[45,46] which is a composite of each parent's self-reported annual income, highest education, and occupation level. Each of these 3 component variables reflect key distinct but interrelated aspects of family socioeconomic position, and composite measures incorporating all 3 variables are commonly used. The measure we used[45] creates a continuous score (ranging from −4.28 to 3.08), reflecting socioeconomic position as follows. First each parents' annual income (derived by converting weekly income from all sources before income tax is taken out to annual income), education level (estimated number of years of schooling), and occupation level (continuous Australian National University score[46] reflecting skills level and occupational prestige) were standardized to have a mean of 0 and a SD of 1. An unweighted average was then calculated relative to the number of parents in the home. The average score within the family was finally restandardized. In line with previous studies,[45,47] we categorized the 25% least socioeconomically advantaged families as "disadvantaged" and the top 75% as "nondisadvantaged." As well as lower relative position in the social hierarchy, this translates to substantial differences in resources in absolute terms; for example in our sample, only 48.0% of parents from disadvantaged families had completed "high school or below," whereas the majority (95.9%) of parents from nondisadvantaged families had completed "above high school" (Supplemental Table 4).

Mediators

Parental mental health (4–5 years). The primary caregiver reported on her or his own mental health using the Kessler Screening Scale.[49] This measure has been widely used as a screening tool for mental health problems in nonclinical populations and was used as it allowed us to capture the broader spectrum of mental health difficulties experienced by parents, including subthreshold difficulties that may be more amenable to change.[50,51] The Kessler Screening Scale asked the parent how often in the past 4 weeks he or she experienced feeling a range of symptoms of psychological distress (eg, "In the past 4 weeks about how often did you feel nervous?"), using a 5-point response scale ("1 = all of the time" to "5 = none of the time"). Total scores were created by reversing the score on each item and then summing scores across all items, with higher scores representing higher levels of psychological distress. In keeping with previous studies,[52] children were coded as having a parent with "low psychological distress" if the parent scored 6 to 13 or "high psychological distress" if the total score was equal or above 14.

Preschool attendance (4–5 years). The primary caregiver reported on the child's attendance (yes or no) at a preschool program across a range of early childhood education and care settings (eg, stand-alone preschools, preschools within long day care centers, preschools attached to schools) in the year before compulsory schooling. Hours of attendance were not captured in the dataset. Children were coded as attending a preschool program if parents reported attendance at a preschool program at any setting, whereas all other children were categorized as not attending.

Outcome

Child mental health problems (10–11 years). Children's mental health problems were assessed using the Strengths and Difficulties Questionnaire (SDQ) - a brief screening measure of behavioural and emotional problems for 3 to 16 year olds.[53] The SDQ contains 25 items that measure 5 subscales with 5 items in each: prosocial behavior, peer relationship problems, emotional symptoms, hyperactivity or inattention, and conduct problems. The SDQ total score is a sum of scores on 20 items (excluding the prosocial behavior subscale), with higher scores representing poorer mental health. The SDQ is used extensively to indicate children with likely mental health problems and shows good psychometric properties (Cronbach's $\alpha = .84$ in our sample). In the current study, parent-reported SDQ ratings were used because parents are valuable informants and observe children across a wide range of contexts.[54] We also conducted a sensitivity analysis using the child-reported SDQ and observed similar findings (Supplemental Information File 4). Based on the Australian norms,[26] children were coded as having "no elevated mental health symptoms" if they scored 0 to 79th percentile or "elevated mental health symptoms" if they scored 80th to 100th percentile.

Confounders

The following baseline and intermediate confounders were selected to reduce the amount of confounding bias in the estimation of the effects of interest and cannot be interpreted in their own right.

SUPPLEMENTAL TABLE 4 Distribution of Weekly Household Income, Highest Household Education Level, and Highest Household Employment Status Among Disadvantaged and Notdisadvantaged Families

Family Socioeconomic Position[a]	Weekly Household Income (Median, IQR)	Highest Household Education Level (*n*, %)		Highest Household Employment Status (*n*, %)		
		Completed Above High School	Completed High School or Below	Full-time	Part-time	Unemployed
Top 75% - not disadvantaged	1145 (807.5–1619.4)	3662 (95.9)	157 (4.1)	3482 (91.2)	203 (5.3)	133 (3.5)
Bottom 25% - disadvantaged	555 (375–800)	662 (52.0)	611 (48.0)	684 (53.7)	122 (9.6)	467 (36.7)

IQR, interquartile range.

[a]Family socioeconomic position was measured in 2004. The 2006 Australian Census data[48] showed that the median weekly household income was $1027, 48.5% reported completion of high school, and 60.7% were employed full time and 27.9% were employed part-time.

Although it used to be common practice, it is now widely recognized that confounder coefficients in regression analyses are not interpretable.[55] All confounders were dichotomized (see Supplemental Information File 1 for rationale).

Baseline confounders (0–1 year). Based on substantive knowledge, we posited 5 baseline confounders at 0 to 1 year (see Supplemental Table 4 for rationale): child sex (female or male), child Indigenous status (no or yes), maternal age at birth ($\geq$27 years or $<$27 years; the continuous variable "age" was dichotomized using the 20th percentile in keeping with previous studies),[56] maternal country of birth (English speaking countries or non-English speaking countries), and maternal English proficiency level (assessed by a trained interviewer through a face-to-face interview; categorized as "very good" versus "good, not good, or not good at all"). Baseline confounders are confounders of exposure-mediator, mediator-outcome, and exposure-outcome associations that are not affected by the exposure. These were selected to reduce residual confounding.

Intermediate confounders (2–5 years). We posited 5 intermediate confounders measured between 2 and 5 years of age: neighbourhood socioeconomic status at 2 to 3 years as measured by the Socioeconomic Indexes for Areas[57] (top 75% - nondisadvantaged or bottom 25% - disadvantaged); family composition at 2 to 3 years (2 parents or lone parent), child disability excluding mental illness at 2 to 3 years (no child disability or child disability), family stressful life events at 2 to 3 years ($\leq$2 stressful life events or $>$2 stressful life events) and child mental health problems at 4 to 5 years as measured by the SDQ (top 20% - elevated symptoms or bottom 80% - no elevated symptoms). Intermediate confounders are distinct from baseline confounders as they are measured after the exposure (socioeconomic position); they are exposure-induced confounders of all mediator-outcome associations. That is, they are considered to be on the path from the exposure to the mediators and the outcome.

SUPPLEMENTAL INFORMATION FILE 2: CHILD MENTAL HEALTH SERVICE USE AND EARLY MENTAL HEALTH PROBLEMS AT 4 TO 7 YEARS.

This supplemental file presents a detailed summary of child mental health service use at 4 to 7 years and the relationship between child mental health service use (4–7 years), early mental health problems (4–7 years), and later mental health problems (10–11 years).

DATA SOURCE

We drew data from 2 sources - the Longitudinal Study of Australian Children (LSAC) and its linked Medicare Benefits Scheme (MBS) data - to identify whether children with mental health problems accessed mental health care at 4 to 7 years. The MBS data captures attendance at services funded by the federal government's MBS, which includes general practitioners and specialists working in private practice (pediatricians, psychiatrists, psychologists, and other allied health professionals). However, MBS data do not capture tertiary community-based mental health services (eg, Child and Adolescent Mental Health Services), fully privately funded consultations not billed to Medicare (the public insurer), hospital inpatient care, or school-based services. The MBS data were successfully linked for 97% of LSAC Wave 1 participants.

MEASURES

First, drawing on the LSAC data, we identified children at age 4 to 7 who had a need for mental health services because of elevated parent-reported mental health symptoms, as measured using the Strengths and Difficulties questionnaire (SDQ).[53] Parent 1 reported on their child's mental health across 4 subscales (peer relationship problems, emotional symptoms, hyperactivity or inattention, and conduct problems), with higher scores representing

SUPPLEMENTAL TABLE 5 Justifications for the Inclusion of All Variables and Pathways Specified in the Conceptual Model, Including Justification of Variable Cut-offs

Type of Variable	Variable	Original Coding (response)	Cut-off Decision and Citation	Relationship With Exposure	Relationship With Mediator and Intermediate Confounder	Relationship With Outcome
Exposure	Family socioeconomic position (0–1 y)	Continuous (−4.28 to 3.08)	Bottom 25% - disadvantage versus top 75% - not disadvantaged[47]	—	• Children from disadvantaged communities have higher odds of preschool nonattendance[18,58]; • children living in low socioeconomic status are at risk for having a parental with mental health problems[59]; • individual-level social status is a covariate that may influence neighborhood socioeconomic status; and [60,61] • Low family socioeconomic position is associated with lone-parental families,[62] child disability[63] family stressful life events,[64] and early childhood mental health problems.[65]	• Findings from previous systematic reviews showed that disadvantaged children had higher risk of experiencing mental health problems.[66–68]
Mediators	Parental mental health (4–5 y)	Continuous (6 to 30)	Low psychological distress (6–13) versus moderate or high psychological distress (14–30)[52]	—	• Parental mental health may interact with preschool attendance, and both of them are associated with children's socioemotional and peer outcomes.[69]	• Children who have a parent with mental health problems are at risk for experiencing mental health problems.[70–72]
	Preschool attendance (4–5 y)	Binary (yes, no)	Yes versus no[73]	—	• Preschool attendance may interact with parental mental health, and both of them are associated with children's socioemotional and peer outcomes.[69]	• Children who attended preschool are likely to have better mental health outcomes than their counterparts who did not.[74]
Outcome	Child mental health problems (10–11 y)	Continuous (0 to 32)	No elevated mental health symptoms (0–79th percentile) versus elevated mental health symptoms (80–100th percentile)[26]	—	—	—
Baseline confounders[a]	Child sex (0–1 y)	Binary (male, female)	Female versus male[75]	• Gender is treated as a covariate for the longitudinal analysis of the relationship between socioeconomic status and child mental health outcomes.[64,76]	• Gender is treated as a covariate variable for the longitudinal analysis of the relationship between socioeconomic status, parental mental health,[59] and preschool attendance[77]; • Gender is a covariate that may influence the relationship between neighborhood socioeconomic status,[78] family composition,[64] family stressful life events,[64] child's chronic conditions,[79] early mental health problems,[64,80] and children's developmental outcomes	• The prevalence of mental health problems varies considerably between boys and girls.[81,82]

SUPPLEMENTAL TABLE 5 Continued

Type of Variable	Variable	Original Coding (response)	Cut-off Decision and Citation	Relationship With Exposure	Relationship With Mediator and Intermediate Confounder	Relationship With Outcome
	Child Indigenous status (0–1 y)	Categorical (no, Aboriginal, Torres Strait Islander, both)	Yes versus no[83]	• Family ethnicity background is a covariate that may influence the relationship between family socioeconomic status and children's mental health outcomes.[76]	• Indigenous families have a higher prevalence of mental health problems than those from non-Indigenous families[84]; • children from Indigenous backgrounds have higher odds of not attending preschool[73]; • family ethnic background is a covariate that may influence the relationship between neighborhood socioeconomic status,[78] family composition,[85] stressful life events,[86] child chronic conditions,[87] early mental health problems,[80,88] and children's mental health outcomes.	• Children from Aboriginal families have higher odds of experiencing mental health outcomes.[78]
	Maternal age at birth (0–1 y)	Continuous (15 to 63)	≥27 y versus <27 y[89]	• Maternal age at birth is a covariate that may influence the relationship between family socioeconomic status and children's mental health outcomes.[76,90]	• Women with older age have higher rates of depression than younger women[91]; • maternal age is a covariate that may influence the relationship between preschool attendance and child mental health[92]; • maternal age is a covariate that may influence the relationship between neighborhood socioeconomic status,[93] family structure,[92] child disability,[94] family stressful life events,[95] early mental health problems,[80,96] and children's mental health outcomes.	• Children of older mothers are at lower risk of behavioral problems compared with offspring of younger mothers.[97,98]
	Maternal country of birth (0–1 y)	Binary (English speaking countries, non-English speaking countries)	English speaking countries versus non-English speaking countries[83]	• Maternal country of birth is a covariate that may influence the relationship between family socioeconomic status and children's mental health outcomes.[90]	• Migrant women experience a higher rate of depressive symptoms than their native-born peers[99]; • maternal country of birth is a covariate that may influence the relationship between preschool attendance and child mental health[100]; • immigration status is a covariate that may influence the relationship between neighborhood socioeconomic status,[100] family structure,[92] child disability,[101] family stressful life events,[102] early life mental health	• Children who have a mother from migration backgrounds are at risk for experiencing mental health problems.[104]

SUPPLEMENTAL TABLE 5 Continued

Type of Variable	Variable	Original Coding (response)	Cut-off Decision and Citation	Relationship With Exposure	Relationship With Mediator and Intermediate Confounder	Relationship With Outcome
					problems,[103] and children's mental health outcomes.	
	Maternal English proficiency level (0–1 y)	Ordinal (very well, well, not well, not at all)	Very good versus good, not good, or not good at all[105]	• Maternal language spoken at home is a covariate that may influence the relationship between family socioeconomic status and children's mental health outcomes.[106]	• Limited English proficiency associated with psychological distress[107]; • children are less likely to attend preschool when they have a primary carer who has difficulties speaking English[108]; • first language spoken at home is a covariate that may influence the relationship between neighborhood socioeconomic status,[100] family structure,[101] child disability,[101] family stressful life events,[80] early life mental health problems,[80,109] and children's mental health outcomes.	• Mother's main language not English is associated with exposure to child mental health problems.[80]
Intermediate confounders[a]	Neighborhood socioeconomic status (2–3 y)	Continuous (670 to 1210)	Bottom 25% - disadvantage versus top 75% - not disadvantaged[110]	—	• Low community socioeconomic status is associated with poor mental health among adults[111]; • children living in disadvantaged communities have substantially higher odds of not attending preschool.[73,112]	• Low neighborhood socioeconomic status is associated with poor mental health outcomes among children.[78,113]
	Family composition (2–3 y)	Binary (2 parents, lone parent)	2 parents versus lone parent[83]	—	• Single-parent families are at risk for experiencing poor mental health among adults[114,115]; • children in single-parent families are less likely to attend preschool than those in couple families[112];	• Children from single parent families are more likely to experience mental health problems.[81,114]
	Child disability excluding mental illness (2–3 y)	Binary (yes or no)	Yes versus no[116]	—	• Child's chronic health conditions are associated with parental mental health[117]; • children with chronic health conditions are more likely to miss preschool.[118,119];	• Children with chronic conditions having higher odds of experiencing mental health problems.[120]
	Family stressful life events (2–3 y)	Count (0 to 16)	2 or less stressful life events versus more than 2 stressful life events[121]	—	• People with more family stressful life events are at risk for poor mental health[122]; • children who experience house moving and other stressful life events are less likely to participate in preschool.[108,118]	• Exposure to family stressful life events is associated with higher odds of experiencing mental health problems among children.[80,123]

SUPPLEMENTAL TABLE 5 Continued

Type of Variable	Variable	Original Coding (response)	Cut-off Decision and Citation	Relationship With Exposure	Relationship With Mediator and Intermediate Confounder	Relationship With Outcome
	Child mental health problems (4–5 y)	Continuous (0 to 34)	Elevated symptoms (top 20%) versus no elevated symptoms (bottom 80%)[26]	—	• Parents are more likely to have poor mental health if their children have mental health problems[124,125], • children with mental health problems are less likely to attend preschool.[119]	• Early childhood mental health problems predict mental health problems at a later age.[126,127]

The main goal in confounder selection is to reduce the amount of residual confounding.[128]

[a]From a causal perspective we are never aiming to interpret effects of confounders in regression models.[55]

poorer mental health.[53] Children were coded as having "no elevated mental health symptoms" if they scored 0 to 79th percentile or "elevated mental health symptoms" if they scored 80th to 100th percentile.[26]

Second, children who received mental health services at 4 to 7 years were identified using 2 indicators: (1) A single-item question from the LSAC on which Parent 1 reported whether the child used a mental health service in the last 12 months (yes or no), measured at 4 to 5 or 6 to 7 years; (2) the linked child MBS data on mental health care utilization from age 4 years through to 7 years. Within the MBS, services are assigned an "item number," corresponding to the health professional who provided the child a service and the type of service provided. Following the approach of Mulraney et al,[129] children were coded as using a mental health service if they used any of the following health professionals or services at age 4 to 7 years: (1) GP mental health assessment and/or treatment; (2) psychologist; (3) psychiatrist; (4) family therapy; (5) allied health (occupational therapist or social worker) delivery of focused psychological strategies; and (6) pediatrician. We included pediatrician visits given that, although MBS items do not provide specific information about whether children attending pediatricians did so for mental or physical health problems, evidence shows that approximately 60% of visits to pediatricians in Australia involve treatment of behavioral or developmental issues.[130] Children were coded as having "access to mental health care" if they were identified as having used a mental health service in either the LSAC or the MBS data.

RESULTS

Supplemental Table 6 shows the proportion of children experiencing elevated mental health symptoms at 4 to 7 years. In the total sample, there was a higher proportion of elevated symptoms amongst children who were socioeconomically disadvantaged (42.1%), compared with not disadvantaged (27.6%).

Access to child mental health care at age 4 to 7 amongst the full sample and those with elevated symptoms are shown in Supplemental Tables 7–9. Among those with elevated symptoms, disadvantaged children (25.4%) received similar amounts of mental health care as children who were not disadvantaged (30.7%).

Supplemental Table 10 shows that children who had elevated symptoms at 4 to 7 years had higher odds (OR = 8.72, 95% CI = 7.28 to 10.45) of experiencing elevated symptoms at 10 to 11 years, after adjusting for baseline confounders and socioeconomic disadvantage. Similarly, children who accessed mental health care at 4 to 7 years had higher odds (OR = 3.36, 95% CI = 2.78 to 4.07) of experiencing elevated symptoms at 10 to 11 years, after adjusting for baseline confounders and socioeconomic disadvantage. There was also a large association (OR = 3.37, 95% CI = 2.82 to 4.03) between elevated symptoms at 4 to 7 years and child mental health care access at 4 to 7 years, after adjusting for baseline confounders and socioeconomic disadvantage.

These results suggest the presence of confounding by indication whereby children with more severe or persistent mental health conditions were more likely to have

SUPPLEMENTAL TABLE 6 Mental Health Problems at 4 to 7 y by Disadvantage Groups for the Total Sample

	Mental Health Problems at 4–7 y		
Group	No Elevated Symptoms	Elevated Symptoms	Total
Nondisadvantaged	2504 (72.5)	952 (27.6)	3456
Disadvantaged	553 (57.9)	402 (42.1)	955
Total	3057 (69.3)	1354 (30.7)	4411

received a substantial level of mental health services. The SDQ is a parent-reported screening tool and not a clinical diagnostic tool of children's mental health problems. Because of lack of data on the nature and severity of children's mental health problems, we did not have access to data that would enable adjustment for confounding by indication. If we included "child mental health service use" as a mediator in our study, the emulated interventional effects would be difficult to interpret. As such, we did not include child mental health service use as a mediator in our study.

SUPPLEMENTAL INFORMATION FILE 3: TECHNICAL DETAILS OF THE ANALYTIC APPROACH

PRELIMINARY ANALYSIS

First, to provide a preliminary examination of the pathways depicted in Figure 1, we used a series of generalized estimating equation models (estimating odds ratios) with an exchangeable working correlation matrix. These preliminary analyses were not used to directly address the causal mediation research question of interest, given the well-known problems of traditional regression-based approaches to mediation.[131] The aim of these preliminary analyses was rather to confirm the expected associations depicted in the DAG in Figure 1. These series of models estimated the associations represented by the following 5 main arrows in the DAG in Figure 1:

1. From the exposure socioeconomic position to the outcome child mental health problems at 10 to 11 years.
2. From the exposure socioeconomic position to the mediator parental mental health at 4 to 5 years.
3. From the exposure socioeconomic position to the mediator preschool attendance at 4 to 5 years.
4. From the mediator parental mental health at 4 to 5 years to the outcome child mental health problems at 10 to 11 years.
5. From the mediator preschool attendance at 4 to 5 years to the outcome child mental health problems at 10 to 11 years.

Each of these associations was estimated with no adjustment for confounding and then with progressive adjustment by the potential confounders for the given association, which can be identified in the DAG as the common causes of the 2 variables involved. Thus, exposure-outcome and exposure-mediator associations were adjusted for baseline (0–1 year) confounders only. Meanwhile, mediator-outcome associations (the last 2 in the list above) were additionally adjusted by the intermediate confounders (2–5 years) as well as the exposure socioeconomic position (which is also a common cause of mediator and outcome and thus mediator-outcome confounder).

SUPPLEMENTAL TABLE 7 Accessed Mental Health Care by Disadvantaged Groups in the Full Sample

	Accessed Mental Health Care at 4–7 Years, *n* (%)		
Group	No	Yes	Total
Nondisadvantaged	3234 (84.7)	585 (15.3)	3819
Disadvantaged	1100 (86.4)	173 (13.6)	1273
Total	4334 (85.1)	758 (14.9)	5092

APPROACH TO ESTIMATING INTERVENTIONAL EFFECTS

The causal mediation research question of interest was addressed directly using the interventional effects approach[132] as outlined by Moreno-Betancur et al.[133] This is a modern approach to mediation analyses with multiple mediators developed in the causal inference literature.[132–136] The interventional effects approach extends traditional regression-based approaches to mediation analysis in allowing appropriate handling of mediator-outcome confounding, exposure-mediator and mediator-mediator interactions and mediator-outcome confounding affected by the exposure (intermediate confounding).[131] These are the most important results presented in the paper as they address our primary question of interest.

For background, the modern causal inference literature has formalized the statistical study of causality. A key feature of developments within this field is that it has clarified the need to move away from a strong reliance on parametric models (eg, multivariable regression, path analysis, structural equation models) to answer causal questions, given the implicit stringent assumptions that are needed to causally interpret the effects estimated. Instead, emphasis is given to more general methods where the causal assumptions are

SUPPLEMENTAL TABLE 8 Accessed Mental Health Care by Disadvantaged Groups Among Children With Elevated Symptoms

	Accessed Mental Health Care at 4–7 Years, *n* (%)		
Group	No	Yes	Total
Nondisadvantaged	660 (69.3)	292 (30.7)	952
Disadvantaged	300 (74.6)	102 (25.4)	402
Total	960 (70.9)	394 (29.1)	1354

explicit, with effects defined in a model-free way in terms of hypothetical interventions.[137–139]

For causal mediation problems, initial developments in the causal literature focused on so-called "natural effects," but these have been the subject of much criticism given their lack of interpretability for informing public health policy.[140] The interventional effects approach used in this study was proposed as an alternative that has several advantages over mediation approaches based on natural effects. In contrast to natural effects that are defined in terms of individual-level effects, interventional effects are population-level quantities, so the effects are interpretable in terms of population-level interventions.[141] Further, interventional effects are estimable even in the presence of intermediate confounding and without making empirically unverifiable assumptions.[132]

In our study, we focused on estimating interventional effects that capture the extent to which mediator interventions would reduce the average (ie, marginally adjusted) absolute risk difference quantifying the association between socioeconomic disadvantage and children's mental health problems, which comprises all pathways in Supplemental Fig 2.[132,134–136,142,144] With some assumptions (see below), this method allowed us to estimate the effect of mediator interventions under the following scenarios: (1a) a pragmatic intervention scenario that would improve the rates of low parental psychological distress and preschool attendance in disadvantaged children (bottom 25% socioeconomic position), making them similar to the rates in their nondisadvantaged peers (top 75% socioeconomic position), (1b) a best-case intervention scenario that would improve the rates of low parental psychological distress and preschool attendance in disadvantaged children, making them similar to the rates in their most nondisadvantaged peers (top 25% socioeconomic position), and (2) a maximum benefit intervention scenario that would eliminate all risk caused by the mediators; that is, all children from disadvantaged backgrounds had parents with low psychological distress and all children attended preschool.

Supplemental Table 11 shows the interpretation of each of the 3 interventional effects of interest to this study in each of the scenarios. These consist of indirect effects capturing the extent to which the risk difference would be reduced by intervening to shift the distribution of each mediator of interest separately, and a direct effect quantifying the socioeconomic gap in children's mental health problems that would remain after intervening to shift the distributions of both mediators.

To implement this approach, we first used standardization (g-computation)[143] to estimate the marginally-adjusted absolute difference in risk of elevated mental health symptoms at 10 to 11 years for children who were disadvantaged versus not disadvantaged at 0 to 1 year. This was done using multivariable logistic regression, including all 2-way exposure, intermediate confounder, and mediator interactions, and then computing margins to get the proportion of children with mental health problems in each socioeconomic group after adjustment. This approach differs from simple multivariable regression approaches in that it allows for exposure-confounder interactions, thus relaxing the assumption of regression that the difference between exposure groups is constant within all subgroups of the population and instead providing an average.

Interventional effects can be estimated using similar regression-standardization techniques facilitated by Monte Carlo simulation.[141] We followed the approach described in Moreno-Betancur et al,[142] which we implemented in R Statistical Software.[144] First, a series of regression models were fitted for the outcome given exposure, mediators, and baseline confounders, and for each mediator

SUPPLEMENTAL TABLE 9 Amount of Mental Health Care Visits by Disadvantaged Groups Among Those Children With Elevated Symptoms

	Amount of Mental Health Care at 4–7 Years, *n* (%)				
Group	No Visits	1–3 Visits	4–7 Visits	≥8 Visits	Total
Nondisadvantaged	705 (74.1)	140 (14.7)	67 (7.0)	40 (4.2)	952
Disadvantaged	322 (80.1)	49 (12.2)	18 (4.5)	13 (3.2)	402
Total	1027 (75.9)	189 (14.0)	85 (6.3)	53 (3.9)	1354

SUPPLEMENTAL TABLE 10 The Estimated Association Between Early Mental Health Problems (4–7 Years), Child Mental Health Care (4–7 Years), and Later Mental Health Problems (10–11 Years)

	Model 1: Unadjusted, OR (95% CI)	Model 2: Adjusted for Baseline Confounders, OR (95% CI)	Model 3: Adjusted for Baseline Confounders + Socioeconomic Disadvantage, OR (95% CI)
Association with children's elevated mental health symptoms, 10–11 y			
Socioeconomic disadvantage, 0–1 y	2.07 (1.73 to 2.49)	1.76 (1.45 to 2.14)	—
Child accessed mental health care, 4–7 y	3.34 (2.77 to 4.02)	3.32 (2.75 to 4.01)	3.36 (2.78 to 4.07)
Child had early elevated mental health symptoms, 4–7 y	9.29 (7.78 to 11.10)	8.84 (7.39 to 10.59)	8.72 (7.28 to 10.45)
Association with children's mental health care, 4–7 y			
Child had early elevated mental health symptoms, 4–7 y	3.34 (2.81 to 3.96)	3.35 (2.81 to 4.00)	3.37 (2.82 to 4.03)

given exposure, subsets of the preceding mediators, and baseline confounders. All of these models included all 2-way interactions amongst exposure and mediators to reduce the risk of model misspecification, as the purpose was to use them for simulating values in the second step. Second, each interventional effect was estimated by drawing mediator values from an appropriate subset of the regression models (and setting to the maximum benefit level where relevant, for the maximum benefit scenario) and taking contrasts of the average predicted probability of the outcome across the simulated values (200 simulations per individual). Each interventional effect is the contrast of 2 weighted averages, where the weights reflect specific population-level interventions on the joint distribution of the mediators.[141] These were further averaged over the marginal distribution of the baseline confounders.

The interventional effects approach allows us to consider the effect of intervening on each mediator individually and also intervening on both mediators concurrently. This is done by simulating shifts in the joint distribution of the mediators. This can be thought of as allowing the effects of the mediators to be interactive rather than additive. In this instance, there appeared to be little evidence of an interactive effect between the 2 mediators. In estimating this joint effect, the approach does not assume that it is the same families that receive the intervention because the procedure is stochastic, so although we draw the mediators after intervention from the joint distribution in the nondisadvantaged given family characteristics, there is random variability incorporated that reflects the natural variation in such a process, including families who would have received one intervention and not the other.

The causal assumptions underlying such interventional effects analysis include no unmeasured confounding and positivity.[142] There are further unverifiable assumptions related to the fact that we are estimating the effects of hypothetical rather than actual mediator interventions. This is a common limitation of longitudinal cohort studies, which is a trade-off with being able to answer questions about long-term outcomes and in the general population to inform the development of future interventions. This particular approach was specifically developed for contexts like the present one where data on actual, well-defined interventions already rolled out in the community are not available. As one would expect, simulation of hypothetical interventions requires more assumptions than if we had data on actual interventions and these should be considered in the interpretation of the findings.[141,145]

MISSING DATA

The proportion of children with missing data across analysis variables ranged from 0% to 32%, and 49% of participants had missing data on at least 1 variable. Such complex multivariable missingness patterns are very common in longitudinal cohort studies like LSAC, and multiple imputation (MI) is now a standard approach to handle missing data in these settings.[146,147] It is preferred over the complete case analysis, as the latter entails a higher risk of selection bias under realistic missingness mechanisms as well as loss of precision.[148] The extent of bias of complete case analysis in this multivariable missingness setting would be extremely difficult to quantify and would depend on unverifiable assumptions.[148] MI is also preferred over weighting approaches in this setting, because the latter approaches are not easy

SUPPLEMENTAL TABLE 11 Definitions of Interventional Indirect and Direct Effects of Interest

Type of Effect	Definition
Scenario 1a: a "pragmatic scenario" of hypothetical interventions improving parental mental health and preschool attendance for disadvantaged children to the level of their nondisadvantaged peers; scenario 1b: a "best-case scenario" of hypothetical interventions improving parental mental health and preschool attendance for disadvantaged children to the level of their most nondisadvantaged peers	
Interventional indirect effect via parental mental health (IIE_1)	Reduction in risk of mental health problems in the disadvantaged group that would be achieved by a hypothetical intervention that increased the level of parental mental health in this group to that of the nondisadvantaged group[a], independently of other mediators.
Interventional indirect effect via preschool attendance (IIE_2)	Reduction in risk of mental health problems in the disadvantaged group that would be achieved by a hypothetical intervention that increased the level of preschool attendance in this group to that of the nondisadvantaged group[a], independently of other mediators.
Interventional direct effect not via M_1 or M_2	Inequities in child mental health problems that would remain if we implemented interventions that jointly increased the level of parental mental health and preschool attendance in the disadvantaged group to that of the nondisadvantaged group[a], independently of the remaining mediators (ie, intermediate confounders).[b]
Scenario 2: a "maximum benefit scenario" of hypothetical interventions eliminating all mediators risk (ie, all children from disadvantaged backgrounds had parents with low psychological distress and all children attended preschool)	
Interventional indirect effect via parental mental health (IIE_1)	Reduction in risk of mental health problems in the disadvantaged group that would be achieved by a hypothetical intervention that ensured all children in this group had parents with low psychological distress, independently of other mediators.
Interventional indirect effect via preschool attendance (IIE_2)	Reduction in risk of mental health problems in the disadvantaged group that would be achieved by a hypothetical intervention that ensured all children in this group attended preschool, independently of other mediators.
Interventional direct effect not via M_1 or M_2	Inequities in child mental health problems that would remain if we implemented interventions that jointly achieved low parental psychological distress and preschool attendance for all disadvantaged children, independently of the remaining mediators (ie, intermediate confounders).

[a] The nondisadvantaged group refers to children in the top 75% socioeconomic position in Scenarios 1 and 2, and children in the top 25% socioeconomic position in Scenario 1b.
[b] We estimated this as the sum of 7 components: interventional direct effect corresponding to an intervention to shift all 7 mediators jointly to that in the nondisadvantaged group; interventional indirect effects corresponding to interventions on each of the 5 intermediate mediators, independent of other mediators; and an interventional indirect effect quantifying the reduction in risk that would be brought about by intervening to bring the interdependence between all the mediators in the disadvantaged group to that in the nondisadvantaged group. The latter term is generally expected to be small.[132] Disadvantage here refers to the 25% least socioeconomically advantaged families.

to implement appropriately with intermittent missingness and, especially, they do not allow inclusion of auxiliary variables, ie, variables not involved in the analysis but that may be predictors of missing values and can be included in MI models to both reduce bias (if also predictors of missingness) and increase precision.[149] In using all available information, including auxiliary variables, and relying on less stringent assumptions about the missingness mechanism, multiple imputation reduces bias and increases precision relative to those 2 approaches and is thus preferred.

We conducted multiple imputation by chained equations in Stata 15.1 (Stata Corp, College Station, TX),[150] producing 50 imputed datasets. Multiple imputation by chained equations is a commonly-used approach to handling missing data.[151] It uses the distribution of the observed data to estimate a set of plausible values for the missing data. We imputed continuous variables using linear regression models and binary variables using logistic regression models under the missing at random assumption. The imputation model in our study included all variables in the analysis model and 4 auxiliary variables (ie, variables that can help to make estimates on missing data but are not part of the main analysis: child age, Parent 2-reported Strengths and Difficulties Questionnaire (SDQ) ratings, teacher-reported SDQ ratings, and child-reported SDQ ratings, all assessed at 10–11 years), as well as all 2-way interactions amongst exposure, intermediate confounders, mediators, and outcome.

Based on the convention that the number of imputations should be at least equal to the percentage of incomplete cases,[151] we created 50 imputed datasets (49% of incomplete cases in the current

SUPPLEMENTAL TABLE 12 Sensitivity Analysis Results When Using Child-report Mental Health Problems

	Model 1: Unadjusted, OR (95% CI)	Model 2: Adjusted for Baseline Confounders, OR (95% CI)	Model 3: Adjusted for Baseline and Intermediate Confounders, OR (95% CI)	Model 4: Adjusted for Baseline, Intermediate Confounders and Socioeconomic Disadvantage, OR (95% CI)
Association with children's elevated mental health symptoms				
Socioeconomic disadvantage	2.04 (1.70 to 2.46)	1.91 (1.57 to 2.33)	—	—
Parent with low psychological distress	0.60 (0.46 to 0.79)	0.61 (0.46 to 0.81)	0.76 (0.57 to 1.01)	0.77 (0.58 to 1.03)
Child attended preschool	0.89 (0.75 to 1.05)	0.90 (0.76 to 1.07)	0.96 (0.81 to 1.15)	0.97 (0.81 to 1.16)
Association with parent with low psychological distress				
Socioeconomic disadvantage	0.52 (0.41, 0.65)	0.59 (0.46 to 0.75)	—	—

study) and then analyzed each dataset individually but identically to obtain a set of parameter estimates. Specifically, the above procedure for estimating interventional effects was repeated in each of 50 imputed datasets. Within each imputed dataset, standard errors for the effects of interest were obtained using the nonparametric bootstrap, with the clustered version used to account for clustering by residential postcode. The results across imputed datasets (point estimates and standard errors) were then combined using Rubin's rules for multiple imputation to obtain overall estimates, standard errors, and confidence intervals.[152]

SUPPLEMENTAL INFORMATION FILE 4: ADDITIONAL RESULTS NOT REPORTED IN THE MAIN DOCUMENT

SENSITIVITY ANALYSIS USING CHILD-REPORT MENTAL HEALTH PROBLEMS AS ALTERNATIVE OUTCOMES

When using child-report SDQ ratings to measure children's mental health problems, we found similar results regarding the expected associations depicted in Figure 1 (Supplemental Table 12). Children from disadvantaged families at 0 to 1 year had higher odds of elevated symptoms at 10 to 11 years (OR = 1.91; 95% CI = 1.57 to 2.33), after controlling for baseline confounders. Children who were socioeconomically disadvantaged had lower odds of having a parent who experienced low psychological distress (OR = 0.59; 95% CI = 0.46 to 0.75) and of attending preschool c(OR = 0.83; 95% CI = 0.71 to 0.97) at 4 to 5 years, after controlling for baseline confounders. There was also small evidence showing that having a parent who experienced low psychological distress (OR = 0.77; 95% CI = 0.58 to 1.03) and attending preschool (OR = 0.97; 95% CI = 0.81 to 1.16) at 4 to 5 years were associated with lower odds of elevated symptoms at 10 to 11 years, after adjusting for baseline confounders, intermediate confounders, and socioeconomic disadvantage.

INTERVENTIONAL EFFECTS - SENSITIVITY ANALYSIS

This sensitivity analysis was conducted to supplement the "pragmatic intervention scenario." Specifically, this analysis estimates the potential reduction in inequities in children's mental health problems from hypothetical interventions that improve levels of parental mental health and preschool attendance in disadvantaged children (bottom 25% socioeconomic position), making the levels the same as for the most advantaged children (top 25% socioeconomic position rather than 75% as in the main text). This analysis was conducted to determine whether larger improvements in disadvantaged children's parental mental health and preschool attendance would be more beneficial for reducing inequities in children's mental health problems than the pragmatic intervention scenario reported in the main document.

This analysis was conducted with a subset of the total sample (n = 2546), including only those children in the bottom 25% and top 25% socioeconomic position. Participant characteristics for this sample are shown in Supplemental Table 13. These findings should be interpreted in light of the smaller sample size, noting less robust estimates and wider confidence intervals.

Preliminary analyses confirmed that the expected associations depicted in Figure 1 were evident in this sample (Supplemental Table 14).

SUPPLEMENTAL TABLE 13 Descriptive Information For All Study Variables ($n = 2546$)

Variable	Observed Data, *n*	Frequency (%)	Socioeconomic Position (%)	
			Top 25%	Bottom 25%
Exposure, 0–1 y				
Socioeconomic position	2546			
Top 25%		1273 (50.0)	—	—
Bottom 25%		1273 (50.0)	—	—
Mediators, 4–5 y				
Parental mental health	1801			
Low psychological distress		1626 (90.3)	986 (93.9)	640 (85.2)
High psychological distress		175 (9.7)	64 (6.1)	111 (14.8)
Preschool attendance	2114			
Attended preschool		1428 (67.5)	853 (73.0)	575 (60.8)
Did not attend preschool		686 (32.5)	316 (27.0)	370 (39.2)
Outcome, 10–11 y				
Child mental health problems	1754			
No elevated symptoms		1379 (78.6)	916 (86.0)	463 (67.2)
Elevated symptoms		375 (21.4)	149 (14.0)	226 (32.8)
Baseline confounders, 0–1 y				
Child sex	2546			
Female		1236 (48.5)	611 (48.0)	625 (49.1)
Male		1310 (51.5)	662 (52.0)	648 (50.9)
Child Indigenous status	2546			
No		2396 (94.1)	1268 (99.6)	1128 (88.6)
Yes		150 (5.9)	5 (0.4)	145 (11.4)
Maternal age at birth, y	2546			
≥27		1978 (77.7)	1231 (96.7)	747 (58.7)
<27		568 (22.3)	42 (3.3)	526 (41.3)
Maternal country of birth	2493			
English speaking countries		2037 (81.7)	987 (79.1)	1050 (84.3)
Non-English speaking countries		456 (18.3)	260 (20.9)	196 (15.7)
Maternal English proficiency level	2541			
Very good		2375 (93.5)	1232 (97.1)	1143 (89.9)
Good, not good, or not good at all		166 (6.5)	37 (2.9)	129 (10.1)
Intermediate confounders, 2–5 y				
Neighborhood socioeconomic status (2–3 y)	2255			
Nondisadvantaged		1669 (74.0)	1076 (88.9)	593 (56.8)
Disadvantaged		586 (26.0)	135 (11.1)	451 (43.2)
Family composition, 2–3 y	2255			
2 parents		1940 (86.0)	1178 (97.3)	762 (73.0)
Lone parent		315 (14.0)	33 (2.7)	282 (27.0)
Child disability, 2–3 y	2251			
No disability		2061 (91.6)	1129 (93.3)	932 (89.5)
Disability		190 (8.4)	81 (6.7)	109 (10.5)
Family stressful life events, 2–3 y	1645			
≤2 stressful life events		1413 (85.9)	898 (88.1)	515 (82.3)
>2 stressful life events		232 (14.1)	121 (11.9)	111 (17.7)
Child mental health problems, 4–5 y	1822			
No		1408 (77.3)	903 (85.3)	505 (66.2)
Yes		414 (22.7)	156 (14.7)	258 (33.8)

Observed data are shown. —, not applicable.

Results from the interventional effects approach (Supplemental Table 15) estimated a confounder-adjusted absolute difference of 17.7% (95% CI = 13.3% to 22.1%) in the prevalence of elevated mental health symptoms for children from the most disadvantaged families compared with their most advantaged peers. Under the pragmatic intervention scenario, this absolute difference in prevalence of elevated mental health symptoms could be reduced by 1.3% by intervening to improve parental mental health, and a further 0.1% by intervening to improve preschool attendance for the most disadvantaged children, making levels of each of these the same as for the most advantaged children. These estimates correspond to relative reductions in 7.2% and 0.8% of the socioeconomic disparity, respectively. After intervening on both parental mental health and preschool attendance, 91.9% of the socioeconomic disparity in mental health problems would remain.

SUPPLEMENTAL TABLE 14 Sensitivity Analysis Results When Comparing the Bottom 25% SEP and the Top 25% SEP (Imputed Sample, n= 2546)

	Model 1: Unadjusted, OR (95% CI)	Model 2: Adjusted for Baseline Confounders, OR (95% CI)	Model 3: Adjusted for Baseline and Intermediate Confounders, OR (95% CI)	Model 4: Adjusted for Baseline, Intermediate Confounders and Socioeconomic Disadvantage, OR (95% CI)
Association with children's elevated mental health symptoms				
Socioeconomic disadvantage	3.32 (2.67 to 4.13)	2.73 (2.14 to 3.49)	—	—
Parent with low psychological distress	0.30 (0.21 to 0.43)	0.31 (0.22 to 0.45)	0.54 (0.36 to 0.82)	0.56 (0.37 to 0.85)
Child attended preschool	0.71 (0.56 to 0.89)	0.74 (0.58 to 0.95)	0.86 (0.65 to 1.13)	0.88 (0.67 to 1.15)
Association with parent with low psychological distress				
Socioeconomic disadvantage	0.35 (0.25 to 0.49)	0.39 (0.27 to 0.56)	—	—
Association with child preschool attendance				
Socioeconomic disadvantage	0.60 (0.50 to 0.72)	0.67 (0.54 to 0.83)	—	—

Baseline confounders controlled for were child's sex, child's Indigenous status, maternal age, maternal country of birth, and maternal English proficiency level. Intermediate confounders controlled for were neighborhood socioeconomic status, family composition, child's disability, family stressful life events and child's mental health problems. —, not applicable.

SUPPLEMENTAL TABLE 15 Results of Evaluation of Mediator Interventions to Reduce Socioeconomic Disparities Using the Interventional Effects Approach When Comparing the Bottom 25% SEP and the Top 25% SEP (Imputed Sample, n = 2546)

Effect	Estimate of Absolute Risk Reduction (%), 95% CI	P	Proportion of Total Risk Reduction (Relative %)	Remaining Disparities
Total adjusted marginal risk difference	17.7 (13.3 to 22.1)	<.01	100.0	—
Risk reduction from intervening on parental mental health	1.3 (0.1 to 2.5)	.04	7.2	16.4 (12.0 to 20.8)
Risk reduction from intervening on preschool attendance	0.1 (−0.7 to 1.0)	.73	0.8	17.5 (13.0 to 22.0)
Risk reduction from intervening jointly on both mediators	1.4 (−0.1 to 3.0)	.07	8.0	16.3 (11.7 to 20.8)

Baseline confounders controlled for were child's sex, child's Indigenous status, maternal age, maternal country of birth, and maternal English proficiency level. Intermediate confounders controlled for were neighborhood socioeconomic status, family composition, child's disability, family stressful life events and child's mental health problems. —, not applicable.

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