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The role of birth cohorts in studies of adult health: the New York women's birth cohort

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Summary

Epidemiological studies investigating associations between early life factors and adult health are often limited to studying exposures that can be reliably recalled in adulthood or obtained from existing medical records. There are few US studies with detailed data on the pre- and postnatal environment whose study populations are now in adulthood; one exception is the Collaborative Perinatal Project (CPP). We contacted former female participants of the New York site of the CPP who were born from 1959 to 1963 and were prospectively followed for 7 years to examine whether the pre- and postnatal environment is associated with adult health in women 40 years after birth. The New York CPP cohort is particularly diverse; at enrolment, the race/ethnicity distribution of mothers was approximately 30% White, 40% Black and 30% Puerto Rican. Of the 841 eligible women, we successfully traced 375 women (45%) and enrolled 262 women (70% of those traced). Baseline data were available for all eligible women, and we compared those who participated with the remaining cohort (n = 579).

Higher family socio-economic status at age 7, availability of maternal social security number, and White race/ethnicity were statistically significantly associated with a higher probability of tracing. Of those traced, race/ethnicity was associated with participation, with Blacks and Puerto Ricans less likely to participate than Whites (OR = 0.5, 95% CI 0.3, 0.8, and OR = 0.5, 95% CI 0.3, 1.0, respectively). In addition, higher weight at 7 years was associated with lower participation (OR = 0.95, 95% CI 0.92, 0.99), but this association was observed only among the non-White participants. None of the other maternal characteristics, infant or early childhood growth measures was associated with participation or with tracing, either overall or within each racial/ ethnic subgroup. Daughters' recall of early life factors such as pre-eclampsia (sensitivity = 24%) and birthweight were generally poor, with the latter varying by category of birthweight with the highest sensitivity for the largest babies (81%) and the lowest sensitivity for the smallest babies (54%). These data reinforce the need to rejuvenate existing birth cohorts with prospective data for life course studies of adult health. Understanding the factors that are associated with tracing and

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Figure S1. Histograms of birthweight for overall eligible population (blue) and participants (black), New York women's birth cohort.

Figure S2. Histograms of weight at 1 year for overall eligible population (blue) and participants (black), New York women's birth cohort.

Figure S3. Histograms of weight at 7 years for overall eligible population (blue) and participants (black), New York women's birth cohort.

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participation in these existing cohorts will help in interpreting the validity and generalisability of the findings from these invaluable cohorts.

Keywords

birth cohorts; recall bias; ethnic origins; childhood weight; socio-economic status

Introduction

Accumulating epidemiological evidence points to a long-term influence of the prenatal and early postnatal environment on adult health.[1–5] In particular, birthweight and other measures of infant size have been negatively correlated with a diverse range of adult diseases including cardiovascular disease, diabetes and psychiatric illness, and positively associated with some adult cancers such as breast cancer.[1,2,6–9] While a number of important birth cohorts have been followed up through adulthood outside of the US,[10,11] most US epidemiological studies of early life influences on adult health have largely been limited to investigating exposures documented on medical records (e.g. birth-weight), or exposures that can be accurately recalled in adulthood (e.g. parental age and birth order).

It has become increasingly clear that in order to fully understand these persistent correlations between birthweight and adult disease, epidemiological studies need to start in pregnancy, and perhaps even before conception, since birthweight itself is a crude proxy for the intrauterine environment.[12,13] Just as measures prior to birth are needed to understand antecedents of birthweight as well as other prenatal exposures that operate independent of birthweight, postnatal measures are also needed to capture the complex interplay linking pre- and postnatal environment to adult health. For example, the rate of postnatal growth and early childhood body size have been shown in some studies to be just as or even more important than birthweight in predicting many adult health outcomes including cardiovascular disease and diabetes.[14,15] Postnatal measures of growth have also been associated with many intermediate markers and adult risk factors for chronic disease including hypertension, lipid profile and body size.[2,14,16] However, a major impediment to fully understanding the relationship between early life factors and development of adult disease comes from a lack of longitudinal data, beginning in the prenatal period and continuing across the life course.

We undertook a study to examine whether exposures early in life were associated with women's health 40 years after birth by recontacting former female participants of the New York site of the Collaborative Perinatal Project (CPP). The CPP collected prenatal sera, questionnaire data and clinical measurements from mothers and their babies and followed the children at regular intervals throughout early childhood. In New York, all women who were born between 1959 and 1963 and prospectively followed for 7 years were recontacted between 2001 and 2006 when adult questionnaire data, blood specimens and mammograms were collected. In this paper, we describe our tracing methods and results, and compare participants in the adult follow-up study with non-participants on parental characteristics, infant characteristics, and early childhood growth and development. In addition, we compare mothers and daughters to investigate changing patterns in sociodemographic and other risk factors across generations.

Methods

Study participants

The CPP was initiated in 1959 to investigate maternal health, reproductive and early childhood development, and health outcomes. The study enrolled pregnant women receiving prenatal care at 12 institutions throughout the United States (including Columbia Presbyterian Medical Center in New York City), and collected detailed prospective data on their pregnancy, childbirth and their children until age 7.[17] Between 1959 and 1963, 2138 births at Columbia Presbyterian Medical Center were included in the CPP; 1026 were female offspring. Of the 1026 girls, 841 were followed until age 7 (82%). These 841 made up the eligible cohort for adult follow-up. Girls who dropped out of the cohort before age 7 were not eligible because of the incomplete postnatal childhood growth data and lack of updated address information.[16] Subjects who remained in the cohort until age 7 years were more likely to be Black (OR = 1.56, 95% CI 1.0, 2.44), more likely to be longer at birth (OR = 1.09, 95% CI 1.02, 1.16), and less likely to have a mother who smoked during pregnancy (OR = 0.65, 95% CI 0.45, 0.95).

Tracing methods

Although baseline epidemiological data exist for all CPP participants across all sites in a publicly available database, name and address information necessary for recontacting individuals is only available through paper records at each of the original recruitment sites. We were able to obtain paper records for 779 (93%) of the 841 eligible girls. These records provided the names and addresses of the mothers or legal guardians at last contact, when the daughter was 7 years old, and this information was used to locate the mothers. We first sent a letter to the mother's or legal guardian's address at last contact to explain the purpose of the adult follow-up and request permission to contact her daughter, and obtain updated contact information for her daughter. We traced participants using free online white pages and fee-based databases [e.g. Autotrack XP (ATXP), http://www.atxp.com or http://www.choicepoint.com]. The fee-based databases allowed us to use additional information, including maternal date of birth and social security number (SSN), when available. We only had maternal SSN for 31.9% of the eligible cohort, as the availability of maternal SSN varied for the cohort since SSNs were not routinely used during this time period (http://www.ssa.gov/history/ssn/ssnchron.html). We made at least six attempts to contact each mother; if the mother was deceased (as determined from exact match on ATXP database or from family member at last known address) or was not located after six attempts, we followed the same procedures to trace the daughter using her last known name and address at age 7. We used ATXP to identify potential addresses for the daughter and sent up to nine letters to these potential addresses. If daughters responded by telephone or returned the form with their updated address, we confirmed their identity and interest in the study and sent them the questionnaire and consent form.

We were able to successfully trace 44.6% of the eligible cohort of 841 ($n = 375$). Of the daughters we traced, 18 (4.8%) refused to participate, 3 (0.8%) were too ill to participate and 16 (4.3%) had died. An additional 76 (20%) indicated by telephone or mail a willingness to participate but failed to complete any portion of the questionnaire. Thus, the participation rate was 70% (262/375) of those traced, and 31.2% of the eligible cohort (262/841). A total of 40% of women traced lived outside of the tri-state area (New York, New Jersey, Connecticut); these women were more likely to participate in the study than women living in the tri-state area (83% vs. 69%). The participants lived in the following locations: 108 (41.2%) in New York, 29 (11.1%) in New Jersey and 6 (2.3%) in Connecticut; the remaining 119 (45.4%) were located in 28 states [including 30 daughters (11.5%) who lived

in Florida], and two US territories (Guam and Puerto Rico). The study was approved by the Internal Review Board at the Columbia Medical Center.

Baseline data

At enrolment or registration in the CPP, the mothers were asked to provide information on age, height, parity, smoking, race and pre-pregnancy weight. Maternal weight was repeatedly measured beginning at intake or initial obstetric examination and continuing into the postpartum period. The CPP protocol also specified defined times for measurements. For example, birthweight was obtained within 1 h of delivery by the CPP observer of labour and delivery using calibrated scales, and crown-heel birth length was obtained using a standardised procedure within 24 h of birth. Gestational age was defined as the time elapsed from first day of the last menstrual period (LMP) to the day of delivery. The measure thus depends upon the integrity of LMP reporting. LMP was established at the initial prenatal registration interview by a trained interviewer.

Information on pregnancy conditions was recorded prospectively at the clinic where mothers received prenatal care, following a uniform protocol. The attending physician recorded the absence or presence of preeclampsia and other maternal conditions including gestational diabetes. Placental weight in grams was measured and recorded according to the Benirschke protocol.[18] Maternal report of smoking behaviour was obtained at the initial prenatal visit. In addition, maternal breast feeding at 1 week after birth was recorded; however, total duration of breast feeding was not. Child physical measurements (weight, height and head circumference) were taken at fixed intervals (birth, 4 months, 1 and 7 years) by direct measurement at the clinic. In addition, some subjects have measurements from a 3- or 4-year visit. In addition to the physical measurements, socio-economic status (SES) was determined from data on maternal and paternal education, occupation and income at enrolment and when the child was 7 years old.[17] Information on income, education and occupation for the head of the household or the main wage earner (most frequently the father) was combined into a continuous SES index with higher scores indicating higher or more privileged SES.[19,20]

Adult data

We sent all daughters who were successfully traced a self-administered questionnaire to obtain information on adult body size (height and weight at 20, 30, 40 years and at the time of the questionnaire), along with other information about sociodemographic characteristics (education, occupation, marital status, income and race), a detailed history of tobacco and alcohol use, and adult health and reproductive events (age at menarche, fertility and hormonal medications and pregnancy history). In the follow-up survey, we offered participants the opportunity to identify their racial or ethnic background in response to an open-ended question (How would you describe your race or ethnicity?) as well as to identify with one or more of the following groups: American Indian or Alaska Native, Asian, Black or African American, Hispanic or Latino, White or Caucasian and other. About 15% of participants (n = 39) selected more than one racial/ ethnic category, with the majority choosing White and Hispanic. Using these self-reported data, we categorised participants into the following single-race groups: (1) Hispanic of any race (those who chose Hispanic origin alone or in combination with other races), (2) non-Hispanic Black (those who chose Black or Black with any race other than Hispanic), and (3) non-Hispanic White (those who chose White or White with any race other than Hispanic and Black). Additionally, daughters were asked to report physical activity, depression (CES-D), medication use, maternal pregnancy conditions and their own birthweight, health behaviours (e.g. mammography utilisation), healthcare access, interpersonal relationships and support, and handedness.

Women who completed the questionnaire were asked to provide us with access to their existing mammogram films and to provide a small blood sample. In the mammogram portion of the study, participants returned a Medical Release Authorization form, which was used to temporarily retrieve films from the medical facility where films were stored. Films were sent to Columbia University and digitised for computer-assisted breast density measurements for use as a marker of future risk of breast cancer. We describe here the completion of the adult data collection from the questionnaire.

Statistical analyses

We first compared characteristics of participants ($n = 262$) to the remainder of the eligible cohort ($n = 579$) using univariable statistics. We used logistic regression[21] to model the probability of participation ($n = 262$) vs. non-participation ($n = 579$), comparing maternal, infant and postnatal weight and height measures. We also assessed family SES, maternal education, maternal race and the availability of maternal SSN on predicting the probability of participation. We first estimated a multivariable model including all of the major maternal [age at enrolment, age at menarche, pre-pregnant body mass index (BMI), pregnancy weight gain, smoking, pre-eclampsia, marital status], infant (gestational age, birthweight, birth length, birth order, year of birth) and childhood (weight and height at 4 months, 1 and 7 years) constructs. Family SES at registration was excluded from these models since it was highly correlated with family SES at age 7 years which was included in the model. We performed secondary analyses on variables with a large degree of information missing (e.g. paternal education, paternal age, placental weight, breast feeding, weight and height at ages 3 and 4) to see if the overall inferences changed with the inclusion of these variables. None of these variables was associated with tracing or participation and thus we excluded them from the multivariable models to maximise the sample size. We estimated parsimonious models by including any of the variables from the multivariable model with a P value <0.20. We then used log likelihood ratio tests to remove variables so that only variables that were statistically significant at $P < 0.05$ were kept in the final parsimonious model.

The same strategy was employed for predicting successful tracing in the eligible cohort and for predicting participation among those successfully traced. In addition, we used relative risk regression (with binominal link) to produce relative risk estimates for the final models because the outcome (participation) was common and the odds ratio (OR) is therefore an overestimate of the relative risk. These relative risk regression models resulted in smaller point estimates, as expected, but were consistent with the logistic models in the choice of covariates; thus only the logistic models are reported. As a supplemental analysis, we then stratified the final models by race/ethnic group to test whether any of the pre- or postnatal variables predicted tracing or participation within each race/ethnic group.

We summarised reproductive, demographic and general health characteristics of the adult daughters using information collected from the questionnaire through frequency distributions for categorical variables and mean, standard deviation and range for continuous variables. We then compared differences between mothers and daughters for variables with comparable data including education, smoking and pre-eclampsia using chi-square statistics. Finally, we compared the sensitivity and specificity of the daughters' recall of birthweight and maternal pre-eclampsia with prospectively recorded information on the birth record to evaluate the sensitivity of self-report of these characteristics.

Results

Table 1 presents descriptive statistics of parental and family characteristics, pregnancy-specific characteristics and childhood anthropometry from birth to age 7 years for the overall sample and compares the women who participated in the adult follow-up with those who did

not participate. Women who participated in the adult follow-up were different from those who did not participate in the following ways: compared with non-participants, participants were more likely to be from families with higher SES (measured at maternal registration and at age 7 years); to have maternal SSN available from their contact sheet (43% vs. 27%); to have a mother and father who completed more years of education (12% of participants vs. 6% of non-participants for >12 years of maternal education, and 15% vs. 12% for >12 years of paternal education); and to have a mother who was White (38% vs. 24%). Participants did not differ appreciably from non-participants in terms of infant and childhood weight and height at birth, 4 months, and 1, 3, 4 and 7 years, or for many of the maternal pregnancy and anthropometric characteristics (e.g. pre-eclampsia, smoking, anthropometric measures, weight gain during pregnancy).

Table 2 summarises the multivariable models predicting overall participation. Column 1 presents the multivariable model of overall participation vs. non-participation, simultaneously adjusting for socio-demographic factors, maternal factors and infant and childhood growth parameters. Two types of variables predict overall participation in this model: maternal race/ethnicity (Black maternal race vs. White (OR = 0.5, 95% CI 0.3, 0.8); Puerto Rican vs. White (OR = 0.5, 95% CI 0.3, 0.9); and availability of maternal SSN on record on the contact sheet (OR = 1.8, 95% CI 1.2, 2.7). Table 2 also reports separate parsimonious models predicting overall participation (Column 2), tracing (Column 3) and participation among those successfully traced (Column 4). Higher family SES at age 7 and available maternal SSN increased the probability of successful tracing by more than two times (highest quartile of SES vs. lowest quartile OR = 2.2, 95% CI 1.5, 3.4; available SSN OR = 2.6, 95% CI 1.9, 3.6). Non-White maternal race was associated with a lower probability of tracing (OR = 0.7, 95% CI 0.5, 1.0 for Black vs. White, OR = 0.6, 95% CI 0.4, 0.9 for Puerto Rican vs. White) and a lower probability of participation among those successfully traced (OR = 0.5, 95% CI 0.3, 0.8 for Black vs. White, OR = 0.5, 95% CI 0.3, 1.0 for Puerto Rican vs. White). In the parsimonious model predicting participation among those traced, higher weight at 7 years was also associated with lower participation (OR = 0.95, 95% CI 0.92, 0.99). Weight at 7 years was also of borderline statistical significance for overall participation among the eligible population (Columns 1 and 2). None of the other maternal, infant and childhood variables were related to tracing and participation.

We further stratified the models in Table 2 by race/ ethnic group (White, Black, Puerto Rican). Availability of SSN (OR = 2.0, 95% CI 1.1, 3.6; OR = 1.5, 95% CI 0.9, 2.4; and OR = 3.7, 95% CI 1.9, 7.3 for Whites, Blacks, and Puerto Ricans, respectively) and high SES (Q4 vs. Q1: OR = 3.2, 95% CI 1.4, 7.4; OR = 1.8, 95% CI 0.9, 3.6; and OR = 1.3, 95% CI 0.5, 3.4 for Whites, Blacks and Puerto Ricans, respectively), was associated with participation but was not statistically significant for all subgroups. The association between weight at 7 years and participation appeared limited to the Black subgroup but was not statistically significant in any subgroup (OR = 0.98, 95% CI 0.93, 1.04; OR = 0.96, 95% CI 0.91, 1.0; and OR = 0.96, 95% CI 0.9, 1.03 for Whites, Blacks and Puerto Ricans, respectively). None of the other prenatal or postnatal growth variables was associated with participation within race/ethnic category (data not shown). We further examined the distribution of key growth variables within each racial/ethnic subgroup. Figures S1–S3 (see Supporting information) show histograms for birthweight, weight at 1 and 7 years for the eligible cohort vs. those who participated in the adult follow-up. These figures are shown overall and by racial category and illustrate that the participants have a similar distribution as the overall eligible population for this cohort.

Because the availability of SSN was important to successful tracing we further examined the predictors of SSN availability. Overall, SSN was available for 31.9% of the eligible population. High SES and later age at birth were both positively associated with SSN

availability (OR = 2.0, 95% CI 1.2, 3.6 for Q4 to Q1 of SES, and OR = 3.2, 95% CI 2.6, 3.9 for year of birth). Table 3 summarises the descriptive characteristics of the participants based on self-reported data from the adult follow-up questionnaire. The average age of participants was 41.8 years (range 38.3–46.1). The average age at menarche was 12.5 years (range 8–19). 73.6% of the participants were parous; the average age of first pregnancy was 23.4 (range 13–42) and the average age at first full-term birth was 26.1 (range 14–42). Self-rating of general health was reported as excellent, very good, good, fair and poor by 24%, 43%, 26%, 6% and <1%, respectively. Average BMI (kg/m^2) at 20, 30 and 40 years was 22.0, 24.2 and 27.2, respectively. 46.9% of the women reported never smoking, 28.7% were former smokers and 26.3% were current smokers.

Table 4 compares descriptive characteristics between mothers and daughters. A total of 16% (41/251) of participant daughters classified themselves differently than the maternal racial categorisation on the birth certificate (both mothers and daughters were classified as having the same race on the birth certificate), with adult race categorised using a three-category race/ ethnicity coding and a four-category coding, which incorporates a multiracial category. Differences in educational attainment between daughters and mothers were not statistically significant ($P = 0.07$), but daughters were more likely to complete more years in school than their mothers (85% of the daughters completed >12 years of education compared with 12% of the mothers). Mothers' ever smoking status was associated with daughters' ever smoking status ($P < 0.01$); 54% of daughters and 51% of mothers reported ever smoking. Maternal pre-eclampsia was unrelated to daughter's pre-eclampsia; a similar proportion in both generations had pre-eclampsia during pregnancy.

Table 5 summarises the validity of daughters' self-reported information on birthweight and maternal pre-eclampsia compared with the prospective information collected at baseline. The sensitivity of self-reported classification of birthweight by category on the questionnaire compared with the birth record is presented. Sensitivity ranged from 54% to 81% and was highest among the largest babies (≥8.5 l bs). Overall, the sensitivity of the self-reported information from the daughter on maternal pre-eclampsia was low at 24%. The sensitivity did not improve among the strata of daughters who themselves reported experiencing pre-eclampsia during pregnancy.

Discussion

After over 35 years, we were able to successfully trace 44% of the eligible women from the New York CPP cohort and enrol 70% of those traced in a follow-up study of early life factors and adult health in women. Overall, and within each racial/ethnic group, participants did not significantly differ from non-participants on a number of maternal, infant and early childhood factors, suggesting that participants and non- participants are reasonably similar in this cohort in terms of pre- and postnatal indicators of growth and development. Availability of maternal SSN and higher family SES was related to a higher probability of successful tracing after 35 years, and non-White race was related to both a lower probability of tracing and a lower probability of participation once traced. We also observed that weight at 7 years was associated with participation; however, this finding was not observed after further stratifying on race/ethnicity. Despite these findings, the follow-up cohort was still very diverse in terms of socio-economic and racial/ethnic status. This may be partially due to racial and economic diversity at the New York site of the original CPP cohort, which ensured that a diverse sample of participants remained at follow-up. Distributions of key growth variables were also similar overall, and within racial/ethnic groups, between participants and the overall cohort.

It is difficult to find other similar birth cohort studies with which to compare our overall participation rates, as other birth cohorts have had more frequent and consistent contact with their members and/or enhanced capability of tracing through national identification systems and health registries. For example, many important findings linking infant characteristics and the early life environment to adult health come from the 1946 and 1958 British Birth Cohorts.[11,22–24] Both cohorts have achieved participation rates of over 60% of original members as they enter midlife. For example, members of the 1946 British Birth Cohort were contacted at age 43 (in 1989), for the 19th follow-up contact since birth, and 63.9% of women (60.8% of the overall sample, $n = 5362$), were successfully contacted and interviewed. The 1958 British birth Cohort[23,24] also achieved similarly high rates of follow-up by midlife: at age 42, investigators collected data on 62.3% ($n = 10\,979$) of the overall sample at birth.[24] The high participation rate was likely to have been enhanced by the multiple contacts throughout adolescence and early adulthood (at ages 7, 11, 16, 23 and 33).

Similarly, the Dunedin Multidisciplinary Health and Development Study conducted in Dunedin, New Zealand in individuals born in 1972–73 has achieved exceptionally high follow-up rates; investigators have contacted participants at multiple times, including birth and 3, 5, 7, 9, 11, 13, 15, 18, 21 and 26 years. The most recent contact was at age 32, with participation by 96% of living participants.[25] Additional lifecourse cohort studies, such as the Aberdeen Children of the 1950's Study,[26] the Lothian Birth Cohort,[27] Newcastle Thousand Families Study[28] and the Hertfordshire Cohort[29] have achieved generally higher follow-up rates than ours. However, these cohorts primarily recruited later in childhood rather than before birth and benefited from the use of National Central Health Registries to enhance follow-up. For example, the Aberdeen Children of the 1950's study traced 99% of their cohort after approximately 40 years and obtained participation in adulthood by 64% of those traced.[26] The Lothian Birth Cohort[27] had a response rate of 46% after almost 60 years and a participation rate of 64% of respondents (29% of eligible). In the Newcastle Thousand Families Study,[28] 50% of the original cohort participated at age 50.

Nonetheless, the CPP cohort is unusual, as it has prenatal sera samples and data collected throughout pregnancy. A growing number of US birth cohorts are now being followed into adulthood, often, like ours, after a long hiatus. The Child Health and Development Studies (CHDS)[30] recruited approximately 20 000 pregnancies among members of the Kaiser Permanente Health Plan between 1959 and 1967, with 19 044 live births. At age 5, 89% of the cohort completed a follow-up. A subset of participants was followed through adolescence. Several adult follow-ups of the CHDS are currently underway. While most other geographical sites of the original CPP have had no contact with their cohort since age 7, some CPP sites have followed subcohorts throughout adolescence and early adulthood. In 1987–91, Klebanoff *et al.* performed a follow-up study of women from the Philadelphia and Providence CPP cohorts who were in their 20s and early 30s for a study of pregnancy outcomes.[31,32] Successful location varied by site; in Philadelphia, which was comprised of a predominantly urban population, 55% of eligible women were located, while in Providence, 77% of eligible women were located.[32] While the overall tracing rates for the New York cohort were lower, considerably more time had elapsed since last contact; sub-populations within the Philadelphia cohort were also followed in 1975–78 and again in 1982–85. A follow-up was also conducted in 1992–94 of the Baltimore CPP cohort at Johns Hopkins Hospital, when participants were age 27–33; 65% of the eligible sample ($n = 1758$ of 2694) were successfully interviewed.[33] Participants were more likely to have mothers who were older, married, with family income above the poverty line and more education. While these sites have conducted follow-up of participants, only New York and Philadelphia CPP sites enrolled large numbers of Hispanics (>25).[17] The New York cohort therefore provides a unique opportunity to understand whether early life factors influence adult health in a multiethnic birth cohort.

In our cohort, similar to others, we have found differences in follow-up and participation across time by sociodemographic variables. Such differences can lead to bias in longitudinal research if the loss to follow-up is differential by exposure and outcome. SES was associated with overall participation in the New York women's birth cohort, specifically with the ability to successfully trace daughters in adulthood. SES was also associated with SSN availability which also affected successful tracing. Other birth cohorts have also reported similar associations between participation and SES.[22–24] In the 1946 British Birth Cohort, social class was associated with participation across the life course (specifically, those who were not traced at age 15 were more likely to be from a lower social class). In the New York women's birth cohort, maternal race was also associated with participation among those eligible, as well as with successful tracing and with participation among those traced. Daughters of mothers with White race/ethnicity were more likely to be traced and to participate compared with those whose mothers were Black or Hispanic. Klebanoff *et al.* observed a similar pattern for tracing by race/ ethnicity in the Providence cohort[32] Other US non-birth cohort studies such as NHANES and other community cohorts have also found race consistently associated with tracing and participation;[34,35] White women were more likely to be traced and to participate than non-White women. In addition, in these longitudinal follow-up studies, education,[34,36] occupation,[36] income and employment status[34] were positively associated with successful tracing and participation. Availability of SSN has also been associated with successful tracing and response.[36]

The under-representation of members of low SES and racial/ethnic minority groups in public health and medical research is a widely recognised problem whose significance is likely to increase given the growing interest in understanding social disparities in health. These groups are not only less likely to be present in commonly used sampling frames (e.g. telephone directories), but are also more difficult to recruit, locate and retain in research studies.[34,36] We suspect that the use of online databases, which rely on financial transactions for obtaining and updating their records, may be partly responsible for the differential participation by SES. Use of methods that could efficiently and successfully locate individuals with limited financial history may potentially improve representation in follow-up studies, but unfortunately such resources are currently very limited in the US.

Although women of lower family SES were more difficult to locate, they were not less likely to participate in the follow-up study than women of higher SES once they were traced. However, participants were more likely to be born to White than Black or Puerto Rican mothers. Prior research has identified a number of reasons for lower research participation of racial/ ethnic minority groups, including health problems, economic hardship, inadequate knowledge or understanding of research objectives, procedures, potential benefits and harm, researchers' attitude, behaviour and biases, communication barriers and study eligibility criteria.[37–41] Mistrust of, and fear of exploitation by the government, clinicians and researchers are additional factors that have been cited as significant barriers to participation in research by Blacks.[40,42] These reasons may also play a role in our cohort. 20% ($n = 76$) of the women who were successfully traced initially expressed interest in participation but failed to provide any follow-up data; these women were more likely to be non-White.

Ultimately, the magnitude and direction of any potential bias resulting from differential participation will depend on the specific exposure and disease association, the absolute size of the association and the relationship of SES and race/ethnicity with the exposure and outcome. For example, if SES is a confounding factor for the association between maternal reproductive factors and childhood growth measures and breast cancer risk, statistical adjustment for SES and stratified analyses, given sufficient numbers, can provide less biased estimates. However, as the main explanatory or exposure variable, differential participation

by socio-demographic variables can produce a more serious bias on the results given that the participation is also affected by the outcome.

In terms of general health indicators, the women who participated in the New York women's birth cohort study as adults were generally similar to other US women comparing national data collected by the Centers for Disease Control and the National Center for Health Statistics. The mean BMI in the New York women's birth cohort was slightly lower (27.2) than the NHANES survey average (28.6) but the NHANES data included all women from 40 to 49 years. A similar proportion of participants (26.3%) were current smokers, compared with 26.1% of US women age 30–44 in 1999–2002.[43] A larger difference was seen, however, for former smokers (28.7% vs. 17.5%), indicating a larger percentage of ever smoking in our cohort.

Differences between mothers and daughters in a number of characteristics were striking. For example, educational differences between mothers and daughters in our cohort reflect in part the secular changes observed across the US. According to the U.S. Census Bureau's Current Population Survey (CPS) data, the proportion of women, aged 25 or older, who had completed high school or college increased from 44% in 1959 to 84% in 2000 (http://www.census.gov). The proportion of daughters and mothers in our sample with at least a high school education is higher than in the CPS data (96% vs. 84% for daughters and 54% vs. 45% for mothers, respectively). Additionally, 79% of daughters had completed more years of education than their mothers, while 20% attained the same educational level as their mothers and <1% received less education than their mothers. These findings suggest that participants in our adult follow-up study represent a socially upwardly mobile sample. This upward mobility was observed across all racial/ethnic groups (73%, 79%, 88% for White, Black and Hispanic, respectively).

An important challenge in long-term life course studies concern changes in the measurement of variables over time and across generations. Race presents an interesting example, with significant shifts over time in the way it has been conceptualised (fixed and biological vs. dynamic and socially defined), collected and assessed (third-party observation vs. self-identification) and categorised (single vs. multiple categories, old vs. new categories).[44–48] Variations in question format, response options and mode of assessment have been shown to produce substantially different racial/ethnic data.[49–51] In our study, 16% of participants were categorised into a different racial category by adult self-report than that recorded in the childhood records. This re-categorisation affected the size of the White subgroup the most, with nearly 32% of Whites re-categorised as Hispanic or Black. For the most part, this included individuals of Hispanic origin other than Puerto Rican who were classified as White according to the original CPP classification.

In addition to comparing race/ethnicity classification between the adult questionnaire and the birth record, we compared daughter's recall of her own birthweight and the presence of maternal preeclampsia with the prospectively collected baseline data. The sensitivity for birthweight and maternal pre-eclampsia were both low, suggesting that these variables cannot be validly recalled in adulthood. Interestingly, we found that the sensitivity of birthweight reporting increased for the larger babies, which could lead to a bias in studies using recalled information from adults. There is a small body of literature on self-report of birthweight,[52–56] which overall reports low estimates of accuracy for self-report of birthweight compared with birth records, as well as other maternal pregnancy variables. Further, some of the reports suggest that other factors may influence the accuracy of self-report, including disease status,[55] age at interview and birth order.[52] While our study was enriched by the prospective data collected until age 7 years, we were limited to retrospective assessment of exposures in adolescence and early adulthood. Such retrospective assessment

is likely to have resulted in a non-differential measurement error of factors such as body size at age 20 and 30.

Understanding the role of the pre- and early postnatal environment on adult health is crucial for both aetiology and prevention research. Given the difficulty of recalling early life events decades later as well as the lack of available records for the majority of birth and postnatal measures, existing birth cohorts of individuals now in adulthood are a national treasure that can be used to answer many important questions about the role of early life on adult health. The New York CPP cohort, in particular, represents a unique cohort of diverse individuals with prospectively collected data including maternal pregnancy sera, questionnaire and clinical measurements from before birth to 7 years. Our study demonstrates both the feasibility of rejuvenating such cohorts as well as the challenges inherent in analysing data from such diverse populations, particularly when study hypotheses and analytic strategies may call for detecting differences across strata. Finding ways to successfully rejuvenate the CPP and other similar US cohorts will ultimately enhance their use and application to many important public health questions as individuals in these cohorts reach mid-life and become at risk for many chronic diseases whose roots maybe traced to early life.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Descriptive statistics for the New York women's birth cohort by baseline parental and childhood characteristics stratified by participation in adult follow-up

	Eligible pool			Non-participants			Participants			
	n	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***	**Mean**	**SD**	***P*-value**
Parental characteristics										
Maternal age at enrolment	841	25.80	5.98	579	25.56	5.93	262	26.33	6.05	0.08
Paternal age at enrolment	732	29.73	7.81	494	29.59	7.86	238	30.03	7.74	0.48
Maternal age at menarche	836	12.88	1.67	574	12.85	1.73	262	12.95	1.56	0.43
Maternal pre-pregnant BMI (kg/m^2)	756	22.55	4.07	516	22.56	4.24	240	22.53	3.68	0.93
Maternal weight gain (kg)	776	10.48	4.87	528	10.47	4.83	248	10.51	4.97	0.91
Gestation at delivery (weeks)	841	39.29	3.00	579	39.21	3.18	262	39.48	2.57	0.20
Parity at enrolment	813	1.18	1.40	554	1.16	1.40	259	1.22	1.41	0.54
Family SES index (registration)	787	51.34	17.34	537	49.98	17.13	250	54.28	17.46	<0.01
Family SES index (age 7)	812	49.72	20.24	564	47.90	19.87	248	53.86	20.51	<0.0001
		%			%			%		
Maternal social security number										
Available	268	31.9		156	26.9		112	42.7		<0.0001
Not available	573	68.1		423	73.1		150	57.3		
Maternal education (years)										
<12	414	51.2		296	53.8		118	45.6		<0.01
12	329	40.7		219	39.8		110	42.5		
>12	66	8.2		35	6.4		31	12.0		
Paternal education (years)										
<12	325	49.6		234	53.1		91	42.5		<0.05
12	248	37.9		156	35.4		92	43.0		
>12	82	12.5		51	11.6		31	14.5		
Marital status										
Single	52	6.2		36	6.2		16	6.1		0.49
Married or living as married	753	89.5		515	89.0		238	90.8		

	Eligible pool			Non-participants			Participants			
	n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*P*-value
No longer married[a]	36	4.3		28	4.8		8	3.1		
Maternal race										
White	236	28.1		137	23.7		99	37.8		<0.001[b]
Black	361	42.9		259	44.7		102	38.9		
Puerto Rican	234	27.8		173	29.9		61	23.3		
Other (Asian, other)	10	1.2		10	1.7		0	0.0		
Year of birth										
1959	133	15.8		85	14.7		48	18.3		0.02
1960	176	20.9		137	23.7		39	14.9		
1961	200	23.8		143	24.7		57	21.8		
1962	218	25.9		140	24.2		78	29.8		
1963	114	13.6		74	12.8		40	15.3		
Maternal breast feeding										
Breast	2	0.3		1	0.2		1	0.5		0.23
Bottle	504	81.0		356	82.6		148	77.5		
Both	116	18.7		74	17.2		42	22.0		
Maternal pre-eclampsia										
Yes	68	8.2		47	8.2		21	8.1		0.99
Possibly	85	10.2		59	10.3		26	10.0		
No	680	81.6		467	81.5		213	81.9		
Maternal smoking										
Never	428	51.8		301	53.0		127	49.2		0.32
Ever	398	48.2		267	47.0		131	50.8		
Childhood anthropometry, birth to age 7										
Birth										
Placental weight (g)	711	446.98	92.10	492	444.48	91.88	219	452.60	92.56	0.28
Birthweight (g)	841	3126.93	488.40	579	3122.00	488.43	262	3137.81	489.09	0.66
Length at birth (cm)	831	49.94	2.36	572	49.93	2.41	259	49.98	2.27	0.76
4 months										
Weight (g)	812	6138.00	776.79	553	6154.66	774.88	259	6102.40	781.15	0.37

	Eligible pool			Non-participants			Participants			
	n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*P*-value
Length (cm)	815	61.55	2.80	556	61.51	2.77	259	61.61	2.87	0.64
1 year										
Weight (kg)	794	9.66	1.22	539	9.69	1.27	255	9.60	1.09	0.26
Height (cm)	811	74.01	3.55	556	74.10	3.74	255	73.81	3.07	0.24
3 years										
Weight (kg)	448	14.91	2.14	290	14.97	2.20	158	14.80	2.03	0.42
Height (cm)	441	94.87	3.82	284	95.01	3.85	157	94.60	3.76	0.27
4 years										
Weight (kg)	602	17.16	3.07	416	17.24	3.20	186	16.96	2.76	0.27
Height (cm)	602	103.24	4.35	416	103.28	4.38	186	103.15	4.27	0.73
7 years										
Weight (kg)	841	24.32	5.34	579	24.53	5.51	262	23.87	4.93	0.08
Height (cm)	835	122.03	5.63	575	122.21	5.77	260	121.64	5.28	0.18

[a]Widowed, divorced, or separated.

[b]*P*-value for White, Black and Puerto Rican only.

Table 2

Multivariable logistic regression models predicting tracing and participation, New York women's birth cohort

	Saturated model predicting participation among eligible	Parsimonious model predicting participation among eligible	Parsimonious model predicting tracing status among eligible	Parsimonious model predicting participation among those traced
	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
SES of family at age 7				
Low Q1	1.00 Reference	1.00 Reference	1.00 Reference	
Q2	1.24 [0.73, 2.11]	1.80 [1.14, 2.84]	1.92 [1.26, 2.91]	
Q3	1.16 [0.68, 1.99]	1.30 [0.82, 2.07]	1.44 [0.95, 2.19]	
HighQ4	1.58 [0.90, 2.75]	2.08 [1.33, 3.25]	2.22 [1.46, 3.38]	
Maternal education				
≥12 vs. <12 years	1.22 [0.82, 1.81]			
Maternal race				
White	1.00 Reference	1.00 Reference	1.00 Reference	1.00 Reference
Black	0.49 [0.31, 0.78]	0.56 [0.39, 0.81]	0.72 [0.50, 1.01]	0.47 [0.27, 0.82]
Puerto Rican	0.53 [0.32, 0.88]	0.52 [0.34, 0.78]	0.61 [0.41, 0.91]	0.53 [0.28, 0.98]
Maternal SSN available	1.77 [1.19, 2.65]	1.95 [1.41, 2.70]	2.60 [1.91, 3.55]	
Maternal age at enrolment	1.01 [0.98, 1.05]			
Maternal age at menarche	1.08 [0.97, 1.22]			
Maternal pre-pregnant BMI (kg/m^2)	1.02 [0.97, 1.08]			
Maternal weight gain (kg)	1.00 [0.96, 1.04]			
Maternal smoking (ever : never)	1.04 [0.72, 1.50]			
Marital status (married vs. single)	1.20 [0.64, 2.27]			
Prior parity	0.93 [0.63, 1.38]			
Pre-eclampsia (Yes: No)	0.79 [0.39, 1.61]			
Year of birth				
1959–61	1.00 Reference			
1962	1.43 [0.92, 2.20]			
1963	1.18 [0.68, 2.06]			
Gestation at delivery (weeks)	1.02 [0.95, 1.09]			
Birthweight (g)	1.00 [1.00, 1.00]			
Birth length (cm)	1.03 [0.90, 1.18]			
Weight at 4 months (g)	1.00 [1.00, 1.00]			
Length at 4 months (cm)	1.05 [0.96, 1.15]			
Weight at 1 year (kg)	1.10 [0.86, 1.40]			
Height at 1 year (cm)	0.95 [0.88, 1.02]			
Weight at 7 years (kg)	0.95 [0.90, 1.00]	0.97 [0.94, 1.00]		0.95 [0.92, 0.99]
Height at 7 years (cm)	1.04 [0.98, 1.09]			

Table 3

Characteristics of the female offspring reported at the adult follow-up of New York women's birth cohort

	n	Mean	SD
Age at questionnaire	262	41.8	1.8
Anthropometry			
BMI at age 20 (kg/m^2)	228	22.01	4.25
BMI at age 30 (kg/m^2)	246	24.17	5.76
BMI at age 40 (kg/m^2)	233	26.97	6.72
Current BMI (kg/m^2)	257	27.24	6.22
Reproductive history			
Age at menarche	251	12.5	1.7
Age at first full-term pregnancy	186	26.2	6.36
		%	
Parity			
0	69	26.4	
1	57	21.8	
2	74	28.4	
3	42	16.1	
4+	19	7.3	
Pre-eclampsia			
No	201	89.7	
Yes	23	10.3	
Demographic			
Race (self-report)			
White	69	26.3	
Black	94	35.9	
Hispanic	99	37.8	
Attained education			
<HS	11	4.2	
HS graduate	30	11.5	
Post-HS education	107	40.8	
College graduate	56	21.4	
Masters degree/some grad school/ doctoral degree	58	22.1	
Marital status			
Single	56	21.4	
Married or living as married	145	55.3	
No longer living as married	61	23.3	
Employment status at interview			
Working full time	157	61.8	
Working part time	28	11.0	
Other	69	27.2	

	n	Mean	SD
Income			
<$14 999	13	5.1	
$15 000-$24 999	18	7.0	
$25 000-$49 999	62	23.7	
$50 000-$69 999	43	16.7	
$70 000-$89 999	39	15.2	
$90 000-$129 999	40	15.6	
>$129 999	43	16.7	
General health characteristics			
Had a mammogram by interview			
No	62	23.7	
Yes	200	76.3	
General health			
Excellent	60	23.6	
Very Good	110	43.3	
Good	67	26.4	
Fair	16	6.3	
Poor	1	0.4	
Smoking			
Never	123	46.9	
Former	70	28.7	
Current	69	26.3	
Alcohol			
Never drank any alcohol	52	19.8	
Ever drank any alcohol	210	80.2	
Current alcohol use			
0 drinks/week	119	46.0	
<7 drinks/week	113	43.6	
>7 drinks/week	27	10.4	

HS, High school.

Table 4

Comparison between mothers and daughters of the New York women's birth cohort

Mother characteristics	**Daughter characteristics**			
Race				
	Non-Hispanic White	**Non-Hispanic Black**	**Hispanic**	**Total**
White	65	1	29	95
Black	1	90	8	99
Puerto Rican	2	0	55	57
Total	68	91	92	251
$P < 0.0001$[a]				
Education				
	<12 years	12 years	>12 years	
<12 years	7	16	95	118
12 years	2	14	94	110
>12 years	1	0	30	31
Total	10	30	219	259
$P = 0.07$[a]				
Smoking				
	Ever	Never		
Ever	83	48	131	
Never	55	71	126	
Total	138	119	257	
$P < 0.01$[b]				
Pre-eclampsia among daughters with gravidity >0				
	Ever	Never		
Ever	2	15	17	
Never	21	185	206	
Total	23	200	223	
$P = 0.69$[a]				

[a] Fisher's Exact test.

[b] Chi-square.

Table 5

Comparison of daughter's reporting as adults of birth-weight and maternal pre-eclampsia with actual medical records, New York women's birth cohort

Self-report	**Recorded at birth**			
Birthweight (lb)	<5.5	5.5–6.9	7–8.4	8.5+
<5.5	14	4	1	0
5.5–6.9	9	70	13	0
7–8.4	1	13	66	3
8.5+	0	1	15	13
Don't know	2	16	16	0
Sensitivity	54%	67%	59%	81%
Sensitivity[a]	58%	80%	69%	81%
Pre-eclampsia	Yes	No		
Yes	5	5		
No	9	158		
Don't know	7	72		
Sensitivity	24%			
Sensitivity[a]	36%			

[a]Excluding 'don't knows'.