Cohort Profile

Cohort Profile: UK Millennium Cohort Study (MCS)

Roxanne Connelly[1]* and Lucinda Platt[2]

[1]Centre for Longitudinal Studies, Institute of Education, 20 Bedford Way, London, WC1H 0AL and
[2]London School of Economics, Houghton Street, London, WC2A 2AE

*Corresponding author. Centre for Longitudinal Studies, Institute of Education, 20 Bedford Way, London, WC1H 0AL.
E-mail: R.Connelly@ioe.ac.uk

Abstract

The UK Millennium Cohort Study (MCS) is an observational, multidisciplinary cohort study that was set up to follow the lives of children born at the turn of the new century. The MCS is nationally representative and 18 552 families (18 827 children) were recruited to the cohort in the first sweep. There have currently been five main sweeps of data collection, at ages 9 months and 3, 5, 7 and 11 years. A further sweep of data collection is planned for age 14 years. A range of health-related data have been collected as well as measures concerning child development, cognitive ability and educational attainment. The data also include a wealth of information describing the social, economic and demographic characteristics of the cohort members and their families. In addition, the MCS data have been linked to administrative data resources including health records. The MCS provides a unique and valuable resource for the analysis of health outcomes and health inequalities. The MCS data are freely available to bona fide researchers under standard access conditions via the UK Data Service (http://ukdataservice.ac.uk) and the MCS website provides detailed information on the study (http://www.cls.ioe.ac.uk/mcs).

Key words: Cohort Study, Longitudinal Data, UK

Key Messages

- Although uptake of the 'measles, mumps and rubella' (MMR) vaccination is high, a number of parents make the 'conscious decision' not to immunize their children with this vaccine.
- Children whose mothers suffer from severe psychological distress are more likely to be obese at age 3 years and to have lower levels of cognitive and social development at age 5 years.
- Light drinking during pregnancy does not impact on the cognitive development or behaviour of children at age 3 or 7 years.
- Infants who are exclusively breastfed in the first months of life are less likely to be hospitalized for diarrhoea or lower respiratory tract infections.

Why was the cohort set up?

The UK Millennium Cohort Study (MCS) is a unique, on-going, multidisciplinary, longitudinal study. The sample consists of children born throughout the UK between September 2000 and January 2002, and there have been five sweeps of data collection to date. The MCS is the youngest of the UK's renowned series of national cohort studies, succeeding the National Survey of Health and Development (NSHD, babies born in 1946), the National Child Development Study (NCDS, babies born in 1958) and the British Cohort Study (BCS, babies born in 1970). Following a 30-year hiatus with no new national cohort study and with increasing policy interest in 'the early years', the UK government commissioned the MCS at the turn of the new millennium. The MCS aims to collect a full and multidisciplinary range of information about the cohort, throughout their lives. This will enable detailed analyses of the inequalities faced by a contemporary cohort of individuals. The MCS data provide the basis for comparisons with previous cohorts, and also facilitate international comparative research.

The MCS is housed at the Centre for Longitudinal Studies (CLS) at the Institute of Education, University of London. CLS also houses the NCDS and the BCS. The MCS is funded by the Economic and Social Research Council (ESRC), as well as a consortium of UK government departments and the three devolved administrations (i.e. the Welsh Government, the Scottish Government and the Northern Ireland Executive). Following ethical approval for the study from an NHS Research Ethics Committee (MREC), informed consent is obtained from parents, as well as from the children themselves as they grow up.

Who is in the cohort?

The MCS population is defined as 'all children born between 1 September 2000 and 31 August 2001 (for England and Wales), and between 24 November 2000 and 11 January 2002 (for Scotland and Northern Ireland), alive and living in the UK at age 9 months, and eligible to receive child benefit at that age'.[1] Eligible children were identified using government child benefit records, a benefit with almost universal coverage. Only a very small group of children, such as asylum seekers, were ineligible. In contrast to the previous UK cohort studies, the MCS sample includes babies born over a full year starting in September 2000. This design provides appropriate data for analysis of seasonal variation and the impact on outcomes of timing of birth.

The sample was constructed to be representative of the total UK population and contains 18 552 families (18 827

children) at baseline. A key asset of the MCS is that certain sub-groups of the population were intentionally over-sampled, namely children living in disadvantaged areas, children of ethnic minority backgrounds and children growing up in the smaller nations of the UK.[1] The disproportionate representation of these groups ensures that typically hard to reach populations are adequately represented and that sample sizes are sufficient for the analysis of ethnic minorities, those from disadvantaged backgrounds and children within each of the UK nations. Around 51% of the baseline sample is male. In relation to ethnicity, at baseline around 82% of the cohort members are White, 2.5% are Indian, 4.8% are Pakistani, 2% are Bangladeshi, 1.3% are Black Caribbean, 2% are Black African and 3% of cohort members have a mixed ethnicity. The sample includes families from across the socio-economic distribution. For example, 9% of fathers and 8% of mothers are from the most advantaged 'professional' social group, whereas 12% of fathers and 14% of mothers are from the 'routine' social group. The sample's disproportionately stratified design necessitates the use of adjusted analyses to provide accurate prevalence estimates and robust standard errors. Such adjustment is straightforward using variables provided with the data and the relevant guidance.[2,3]

How often have they been followed up?

The MCS sample members were first surveyed when they were around 9 months of age (MCS1), and cohort members continue to remain eligible to be surveyed if they remain living in or return to the UK. Follow-ups have currently been conducted at ages 3 (MCS2), 5 (MCS3), 7 (MCS4) and 11 years (MCS5). A further sweep of data collection is currently under preparation for age 14 years (MCS6). The sample sizes at each sweep of data collection are presented in Table 1.

The longitudinal pattern of response in the MCS is complex, with attrition, re-entry and a small number of late entrants who were eligible at MCS1 but were not included as they had not yet been registered. At each sweep there has been non-response owing to refusal and non-contact. There are also a small number of families who become ineligible due to emigration or death of the child. The MCS employs a range of office-based and field-based tracking procedures including the use of a free phone number, e-mail address and website. Contact detail self-reply slips are circulated to cohort members annually. Families who have moved and not provided follow-up contact details are tracked via post office, electoral and phone records, and through 'stable contacts' that they have previously supplied. In the field, interviewers also contact the new

property occupiers, neighbours, estate agents and other local sources to attempt to identify the cohort member's new address for those who have moved.[4] These procedures have been highly effective in keeping in touch with the cohort families.[5] Nevertheless, non-response rates (whether through non-contact or refusal) in each sweep have been

consistently higher for families in ethnic or disadvantaged areas compared with families in advantaged areas, in all UK countries.[6] Due to these differential patterns of response, weights are also provided in the deposited data to adjust for inter-wave attrition.

What has been measured?

The MCS is a truly multidisciplinary study and contains an extremely rich range of information regarding the experiences and outcomes of the MCS children and their families. The main health and medical data collected to date are listed in Table 2. There are repeated measures for several topics (e.g. weight and height), and data are available which focus on particular stages of the life course (e.g. pregnancy, birth, infant development, puberty). The MCS data also cover topics such as parenting practices, child care arrangements, parental employment, income, housing, family formation and dissolution, cognitive development, educational attainment, behaviour and physical growth, to name but a few. Notably, the MCS collects data from both co-resident parents, providing information on the influence and roles of fathers, and includes some information on

Table 1. The UK Millennium Cohort Study, dates of contact and samples sizes

Sweep	Year	Age	Issued sample (families[a])	Achieved sample (families[a])
MCS1	2001–02	9 months	21 180	18 552
MCS2	2003–04	3 years	19 244[b]	15 590
MCS3	2006–07	5 years	18 528	15 246
MCS4	2008–09	7 years	17 031	13 857
MCS5	2012–13	11 years	16 393	13 287

[a]There are 253 sets of twins and 11 sets of triplets in the MCS sample. A very small number of households also contain multiple cohort members as the result of two separate pregnancies during the sample eligibility period.

[b]The MCS2 issued sample comprises the 18 552 sample members who took part in MCS1 and 1389 'new families' who were eligible at MCS1 but whose addresses were not recorded on the Child Benefit register (e.g. due to recent home moves). From these identified 'new families', 692 were successfully recruited.

Table 2. The UK Millennium Cohort Study, summary of health and medical data collected.

Sweep	Data collected from	Health and medical data
MCS1	Main parent; second co-resident parent	Fertility treatment; antenatal care; health problems during pregnancy (e.g. hypertension); mode of delivery; pain relief during labour; complications during birth; birthweight and gestational age; breastfeeding; immunizations; incidence of and number of health problems (e.g. chest infections, ear infections, skin problems); accidents and injuries; hospital visits/admissions; developmental milestones; parental health; parental longstanding illness and disability; parental mental health; self-reported parental height and weight; mother's smoking before, during and after pregnancy; mother's alcohol consumption before, during and after pregnancy
MCS2	Main parent; second co-resident parent; older siblings (England only); child assessments and measurements	Immunizations; incidence of and number of health problems (e.g. chest infections, ear infections, skin problems); accidents and injuries; hospital visits/admissions; developmental milestones; parental health; parental longstanding illness and disability; parental mental health; self-reported parental height and weight; child sight and hearing problems; child long-standing health conditions; child cognitive assessments; child height[a] and weight;[a] parental smoking; parental alcohol consumption
MCS3	Main parent; second co-resident parent; older siblings (England only); child assessments and measurements; teachers	MCS2; child waist measurement[a]
MCS4	Main parent; second co-resident parent; child assessments and measurements; child self-completion; teachers	MCS2; child body fat percentage;[a] child waist measurement[a]
MCS5	Main parent; second co-resident parent; child assessments and measurements; child self-completion; teachers	MCS2; child body fat percentage;[a] parental reports on pubertal development; child self-response well-being and happiness measures; self-response child's smoking and alcohol consumption

[a]Direct measures carried out by trained interviewers to standardized protocols.

non-resident parents.[7,8] The original survey documents can be viewed on the MCS web pages (http://www.cls.ioe.ac.uk/mcs) and the online MCS data dictionary provides details of all available variables (http://www.cls.ioe.ac.uk/datadictionary).

In addition to the main survey, there have been a series of enhancement studies that have collected: oral fluid from the children in order to measure their exposure to common childhood infections at MCS2 ($n = 11\,027$, note that these samples were not used for DNA extraction); direct measures of physical activity using accelerometers at MCS4[9] ($n = 6675$), and at MCS4, the sample members were also asked to donate shed teeth as part of the 'Every Tooth Tells a Story' project on environmental lead exposure ($n = 3031$). Data from the oral fluid and physical activity projects have been deposited with the UK Data Service under standard access conditions. As depletable biological samples, the teeth can be accessed for analysis subject to an application to the Access Committee for CLS Cohorts (ACCC) (http://www2.le.ac.uk/projects/birthcohort) and appropriate ethical approval.

Sub-studies of the MCS cohort have also been conducted. A postal survey was sent to health visitors working in areas covered by the MCS, in order to gather information on the health and social care services available to MCS families ($n = 302$). In 2003 a postal survey collected information from 230 mothers of cohort members who had been conceived as the result of successful assisted fertility treatment. Specialist pre-school researchers also visited the nurseries, playgroups and pre-schools of a sample of 300 cohort members during the summer of 2005. Information was collected regarding the type and quality of child care and pre-school educational provision attended by a sample of the cohort members. The MCS data have also been enhanced to provide unique and valuable data resources through data linkage with administrative records. MCS data has been linked to birth registration records, hospital records, fine grained geographical grid references and educational records.[10–12]

What has it found? Key findings and publications

A range of research has been undertaken using the MCS, much of which is documented in the CLS bibliography (www.cls.ioe.ac.uk/bibliography). MCS research has been published in books, journal articles and reports and MCS research has contributed to development of government policy. This brief review is far from exhaustive; however, it describes several illustrative themes of health research undertaken using the MCS.

Prenatal and perinatal antecedents of health problems

A number of studies have looked at mothers' health-related behaviours before, during and after pregnancy and the impacts that these may have on the health of young children. In particular, a number of studies have focused on maternal smoking, as the MCS includes information on the smoking behaviour of mothers before, during and after their pregnancy. Ward et al.[13] examined the smoking behaviour of the MCS mothers, around 36% of whom smoked at some point during pregnancy. Those cohort members who were exposed to cigarette smoke had lower birthweights than those who were not exposed. Further research has utilized the MCS to analyse the reasons why mothers continue to smoke throughout pregnancy. Pickett et al.,[14] for example, highlighted the importance of the mother's interpersonal relationships for the successful cessation of smoking in the first months of pregnancy. Maternal mental health in the first years of life has also been shown to influence the health and developmental outcomes of children. The children of mothers who experienced serious psychological distress were at increased risk of obesity at age 3 years[15] and also had lower levels of social and cognitive development at age 5 years.[16]

Similarly, the cohort member's prenatal exposure to alcohol has also been studied, with Kelley et al.[17] finding that children born to mothers who drank only one or two alcoholic drinks per week were not at increased risk of behavioural problems or cognitive deficits at age 3 years. Analysing behavioural problems and cognitive test performance at age 7 years, Kelley et al.[18] again demonstrated that light drinking during pregnancy was not detrimental.

Breastfeeding

The MCS also provides information regarding the initiation and duration of breastfeeding. Breastfeeding is considered to protect against illnesses in infancy and may also have long-term health benefits.[19] Quigley et al.[20] found that cohort members who were exclusively breastfed in the first months of life were less likely to be hospitalized for diarrhoea or lower respiratory tract infections. Del Bono et al.[21] also found benefits of breastfeeding at ages 4 and 8 weeks for the cognitive development of children at 3 and 7 years.

Numerous analyses of the MCS have also considered the propensity of mothers to breastfeed. Maternal employment was found to be related to the likelihood that a mother would choose to breastfeed.[22] Mothers who were employed full time were less likely to initiate breastfeeding than mothers who were not employed. Mothers who

returned to work within 4 months were also less likely to undertake breastfeeding than those who returned to work after a longer period of time.[22] Looking at the influence of social and demographic factors on the initiation of breast-feeding, mothers of White ethnicity, younger mothers, mothers with low levels of education and mothers living in disadvantaged communities were least likely to breastfeed.[23]

Immunization

The MCS also contains information regarding the uptake of medical services available to the cohort members, such as immunization. Although uptake of the 'measles, mumps and rubella' (MMR) vaccination is high in the MCS, a number of parents made the 'conscious decision' not to immunize their children with this particular vaccine.[24] At 9 months of age, those cohort members who had not received all those immunizations available to them were more likely to live in minority ethnic or disadvantaged areas of England, live in larger families or come from lone parent families.[25] Pearce *et al.*[26] also found that those co-hort families who moved home more frequently were more likely to have children who were only partially immunized. However, those children who were completely unimmu-nized were more likely to have more educated mothers and older mothers.[25]

Childhood weight

Overweight and obesity are a major public health problem, and the MCS includes measures of child weight at each sweep. MCS1 also documents the cohort members' birth-weight, and this variable has been shown to have a high de-gree of congruence with official records.[27] At age 3 years, birthweight, Black ethnicity, early introduction to solid foods, smoking during pregnancy, parental overweight and maternal employment over 21 h per week were found to be associated with childhood obesity.[28] At age 5 years, influences on childhood overweight include breastfeeding for less than 4 months. Children of Indian ethnicity were the least likely to be overweight or obese at this age.[29] Again at age 5 years, overweight cohort members were those with a higher birthweight.[29] Higher levels of parental edu-cation, but not higher levels of income, were found to be associated with a lower likelihood of obesity.[29] At age 7 years, the BMI of the MCS children was again analysed. Those with higher birthweights and those from Pakistani, Bangladeshi and Black ethnicities were more likely to be overweight. Parental social class was not found to be asso-ciated with childhood overweight, whereas parental educa-tion was associated with a reduced risk of overweight at this age.[30]

What are the main strengths and weaknesses?

The multidisciplinary nature of the MCS means that there is not the high level of detailed health-related information included in the survey which health researchers might crave (e.g. blood samples, DNA, blood pressure). However, there is a wealth of health data available in the study, and the multidisciplinary nature of the MCS pre-sents the opportunity to study health from an ecological perspective, by considering the influences of social, economic and demographic factors on health. The MCS therefore presents an excellent resource to facilitate inter-disciplinary research on important public health issues, and comparisons with other medical and non-medical cohorts internationally as well as nationally.

The intergenerational information collected in the MCS (i.e. information about the cohort members' parents) also provides an important basis for understanding the develop-ment of health outcomes and how health inequalities are transmitted throughout families. The MCS can also be analysed alongside the three earlier UK cohort studies of babies born in 1946, 1958 and 1970. The four cohort stud-ies have collected similar information regarding pregnancy and childbirth, childhood illness and childhood growth and development, which could be used in future research to study changes in the health of populations and health inequalities over time.

Can I get hold of the data? Where can I find out more?

The MCS is conducted by the Centre for Longitudinal Studies at the Institute of Education, University of London, under the direction of Professor Emla Fitzsimons. CLS is an ESRC Resource Centre, and offers support and advice to data users. The MCS website, with documentation for the cohort and detailed information about current research and publications, is available at: http://www.cls.ioe.ac.uk/mcs. Data from the MCS surveys are held and distributed by the UK Data Service (http://ukdataservice.ac.uk), and are freely available to researchers under standard condi-tions. A list of all data files deposited with the UK Data Service is available at: http://discover.ukdataservice.ac.uk/series/?sn=2000031.

The oral fluid and physical activity data sets are also de-posited with the UK Data Service, as are the health visitor data. Some MCS data sets contain more sensitive informa-tion (e.g. detailed geographical information, linked admin-istrative and survey data) and these can be accessed through the Secure Data Service, within the UK Data Service. Access to the teeth sample is via the Access

Committee for CLS Cohorts (ACCC) at: http://www2.le. ac.uk/projects/birthcohort.

References

1. Plewis I. *The Millennium Cohort Study: Technical Report on Sampling*. London: Centre for Longitudinal Studies, 2007.
2. Ketende S, Jones E. *User Guide to Analysing MCS Data using Stata*. London: Centre for Longitudinal Studies, 2011.
3. Jones E, Ketende S. *User Guide to Analysing MCS Data using SPSS*. London: Centre for Longitudinal Studies, 2010.
4. Calderwood L. The role of respondent characteristics in tracking on longitudinal surveys: evidence from the UK Millennium Cohort Study. *Longitudinal and Life Course Studies* 2013;**4**:105–18.
5. Calderwood L. *Keeping in Touch With Mobile Families in the UK Millennium Cohort Study*. London: Centre for Longitudinal Studies, 2010.
6. Ketende S. *Technical Report on Response*. London: Centre for Longitudinal Studies, 2010.
7. Tanaka S, Waldfogel J. Effects of parental leave and work hours on fathers' involvement with their babies: evidence from the Millennium Cohort Study. *Community, Work and Family* 2007;**10**:409–26.
8. Kiernan K. Non-residential fatherhood and child involvement: evidence from the Millennium Cohort Study. *J Soc Policy* 2006;**35**:651–69.
9. Griffiths L, Cortina-Borja M, Sera F *et al*. How active are our children? Findings from the Millennium Cohort Study. *BMJ Open* 2013;**3**:e002893.
10. Hockley C, Quigley M, Johnson J, Rosenberg R, Dezateux C, Joshi H. *Millennium Cohort Study: Birth Registration and Hospital Episode Statistics Linkage. A Guide to the Dataset*. London: Centre for Longitudinal Studies, 2007.
11. Johnson J. *Millennium Cohort Study: Geographic Identifiers in MCS*. London: Centre for Longitudinal Studies, 2009.
12. Johnson J, Rosenberg R. *Millennium Cohort Study Fourth Survey. A Guide to the Linked Education Administrative Datasets*. London: Centre for Longitudinal Studies, 2011.
13. Ward C, Lewis S, Coleman T. Prevalence of maternal smoking and environmental tobacco smoke exposure during pregnancy and impact on birth weight: retrospective study using Millennium Cohort. *BMC Public Health* 2007;**7**:81.
14. Pickett K, Wilkinson R, Wakschlag L. The psychosocial context of pregnancy smoking and quitting in the Millennium Cohort Study. *J Epidemiol Community Health* 2009;**63**: 474–80.
15. Ramasubramanian L, Lane S, Rahman A. The association between maternal serious psychological distress and child obesity age 3 years: a cross-sectional analysis of the UK Millennium Cohort Data. *Child Care Health Dev* 2013;**39**:134–40.
16. Mensah F, Kiernan K. Parents' mental health and children's cognitive and social development: families in England in the Millennium Cohort Study. *Soc Psychiatry Psychiatr Epidemiol* 2010;:1023–35.
17. Kelly Y, Sacker A, Gray R, Kelley J, Wolke D, Quigley M. Light drinking in pregnancy, a risk for behaviour problems and cognitive deficits at 3 years of age? *Int J Epidemiol* 2009; **38**:129–40.
18. Kelly Y, Iacovou M, Quigley M *et al*. Light drinking versus abstinence in pregnancy – behavioural and cognitive outcomes in 7-year-old children: a longitudinal cohort study. *BJOG* 2013;**120**:1340–47.
19. Lawrence R. Breastfeeding: benefits, risks and alternatives. *Curr Opin Obstet Gynecol* 2000;**12**: 519–24.
20. Quigley M, Kelly Y, Sacker A. Breastfeeding and hospitalization for diarrheal and respiratory infection in the United Kindom Millennium Cohort Study. *Pediatrics* 2007;**119**:e837.
21. Del Bono E, Rabe B. *Breastfeeding and Child Cognitive Outcomes: Evidence From a Hospital-Based Breastfeeding Support Policy. Working Paper No. 2012-29*. Colchester, UK: University of Essex Institute for Social and Economic Research, 2012.
22. Hawkins S, Griffiths L, Dezateux C, Law C. Maternal employment and breast-feeding initiation: findings from the Millennium Cohort Study. *Paediatr Perinat Epidemiol* 2007;**21**:242–47.
23. Griffiths L, Tate A, Dezateux C. The contribution of parental and community ethnicity to breastfeeding practices: evidence from the Millennium Cohort Study. *Int J Epidemiol* 2005;**34**:1378–86.
24. Pearce A, Law C, Elliman D, Cole TJ, Bedford H. Factors associated with uptake of measles, mumps, and rubella vaccine (MMR) and use of single antigen vaccines in a contemporary UK cohort: prospective cohort study. *BMJ* 2008; **336**:754–57.
25. Samad L, Tate A, Dezateux C, Peckham C, Butler N, Bedford H. Differences in risk factors for partial and no immunisation in the first year of life: prospective cohort study. *BMJ* 2006; **332**:1312–14.
26. Pearce A, Elliman D, Bedford H, Law C. Residential mobility and uptake of childhood immunisations: Findings from the UK Millennium Cohort Study. *Vaccine* 2008;**26**:1675–80.

27. Tate A, Dezateux C, Cole TJ, Davidson L. Factors affecting a mother's recall of her baby's birth weight. *Int J Epidemiol* 2005;**34**:688–95.

28. Hawkins S, Cole TJ, Law C. An ecological systems approach to examining risk factors for early childhood overweight: findings from the UK Millennium Cohort Study. *J Epidemiol Community Health* 2009;**63**:147–55.

29. Brophy S, Cooksey R, Gravenor M *et al*. Risk factors for childhood obesity at age 5: Analysis of the Millennium Cohort Study. *BMC Public Health* 2009;**9**:467.

30. Connelly R. *Drivers of Unhealthy Weight in Childhood: Analysis of the Millennium Cohort Study*. Edinburgh: Scottish Government, 2011.