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## Cohort Profile: The Gateshead Millennium Study

Kathryn N Parkinson, Mark S Pearce, John J Reilly, Robert F Drewett,  
Charlotte M Wright, Ann S Le Couteur, Ashley J Adamson

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### Cohort Profile: The Gateshead Millennium Study

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4 **Cohort Profile: The Gateshead Millennium Study**  
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8 Kathryn N Parkinson<sup>a</sup>, Mark S Pearce<sup>b</sup>, Anne Dale<sup>c</sup>, John J Reilly<sup>d</sup>, Robert F  
9

10 Drewett<sup>e</sup>, Charlotte M Wright<sup>f</sup>, Caroline L Relton<sup>g</sup>, Paul McArdle<sup>h</sup>, Ann S Le  
11

12 Couteur<sup>b</sup>, Ashley J Adamson<sup>a</sup>  
13  
14

15  
16  
17 Institute of Health and Society<sup>a</sup>, Human Nutrition Research Centre, William Leech  
18

19 Building, Framlington Place, Newcastle University, Newcastle upon Tyne, NE2 4HH,  
20

21 UK  
22  
23

24  
25  
26 Institute of Health and Society<sup>b</sup>, Newcastle University, Sir James Spence Institute of  
27

28 Child Health, Royal Victoria Infirmary, Newcastle upon Tyne, NE1 4LP, UK  
29  
30

31  
32  
33 Gateshead Health NHS Foundation Trust, Children's Department<sup>c</sup>, Queen Elizabeth  
34

35 Avenue, Sheriff Hill, Queen Elizabeth Hospital, Gateshead, NE9 6SX, UK  
36  
37

38  
39  
40 Division of Developmental Medicine<sup>d</sup>, University of Glasgow, Faculty of Medicine,  
41

42 Queen Mother's Tower, Yorkhill Hospitals, Glasgow, G3 8SJ, UK  
43  
44

45  
46  
47 Department of Psychology<sup>e</sup>, Science Laboratories, South Road, Durham University,  
48

49 Durham, DH1 3LE, UK  
50  
51

52  
53  
54 PEACH Unit<sup>f</sup>, University of Glasgow, Faculty of Medicine, Queen Mother's Tower,  
55

56 Yorkhill Hospitals, Glasgow, G3 8SJ, UK  
57  
58  
59  
60

1  
2  
3 Institute of Ageing and Health<sup>g</sup>, Newcastle University, Sir James Spence Institute of  
4 Child Health, Royal Victoria Infirmary, Newcastle upon Tyne, NE1 4LP, UK  
5  
6  
7  
8

9  
10 Northumberland, Tyne & Wear NHS Trust<sup>h</sup>, Child and Adolescent Mental Health,  
11 Burdon Terrace, Jesmond, Fleming Nuffield Unit, Newcastle upon Tyne, NE2 3AE,  
12 UK  
13  
14  
15  
16

17  
18  
19  
20 <sup>a</sup>Corresponding author:

21  
22 Dr Kathryn Parkinson, Institute of Health and Society, Human Nutrition Research  
23 Centre, Room M1 151, 1st Floor William Leech Building, Framlington Place,  
24 Newcastle University, Newcastle upon Tyne, NE2 4HH, UK.  
25  
26  
27  
28

29 Tel: (0191) 2223828 Fax: (0191) 2225581 Email: kathryn.parkinson@ncl.ac.uk  
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### 34 **Key messages**

35  
36 The Gateshead Millennium Study recruited a socially diverse birth cohort in  
37 1999/2000. The current sample is representative of the north of England.  
38  
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42  
43 The cohort provides a rich dataset on children's early eating characteristics, dietary  
44 intake, physical activity, and developmental psychopathology.  
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50  
51 The study will allow examination of the development of childhood obesity, and the  
52 development of preventative strategies.  
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56  
57  
58 **Word count:** 3315 (main body of paper, ie excluding title page, contributor's list,  
59 references and tables)  
60

### **How did the study come about?**

The Gateshead Millennium Baby Study (GMBS) originated from the observation that slower than expected weight gain in infancy, traditionally known as failure to thrive, but more recently as 'weight faltering', had never been satisfactorily explained. There were methodological problems associated with much previous research. The first was the use of attained weight criteria to identify slow weight gain in infancy, which confounds poor postnatal weight gain with poor prenatal weight gain. The second was the use of referred samples of children, leading to selection biases. The third was the use of retrospective accounts from parents after poor weight gain had already been identified. The GMBS was thus originally designed to investigate the antecedents of weight faltering in a population based prospective study which addressed the main methodological problems of previous research.

### **What does it cover?**

The original GMBS set out to examine infant feeding behaviour and relate it to subsequent weight gain and weight faltering. It also investigated risk factors for iron deficiency in infancy. Relevant maternal characteristics including feeding style, eating attitudes and depression were also examined. More recently the title of the study has been changed to Gateshead Millennium Study (GMS) to reflect the age of the cohort. The study has continued to focus on feeding and growth, with three additional areas of interest emerging.

First, it investigated aspects of developmental psychopathology using measurements principally taken at 5-6 years of age. A recent UK prevalence survey in 5-19 year olds reported that mental health disorders are common, affecting approximately 8%

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2  
3 and that sub-threshold symptoms were even more common.<sup>1</sup> Eating disorders  
4  
5 comprise an important social and medical problem developing over late childhood.  
6  
7 Accurate figures on the prevalence of eating disorders have not been easy to establish.  
8  
9 Those in a recent comprehensive review suggest a prevalence of 0.28% for anorexia  
10  
11 nervosa, 1% for bulimia nervosa, 1.5% for night eating syndrome and 2.3% for binge  
12  
13 eating disorder.<sup>2-4</sup> A much higher proportion of young women report less specifically  
14  
15 diagnosable problems such as occasional binge eating or self induced vomiting or  
16  
17 score high on tests of abnormal eating attitudes.<sup>5</sup> There is also evidence that sub-  
18  
19 threshold eating disorders are commonly associated with depression in adolescents,  
20  
21 and there is a strong link between restrictive eating and aggression, attempted suicide  
22  
23 and substance misuse.<sup>6,7</sup> Most longitudinal studies of disordered eating have started  
24  
25 in the teenage years, but the strongest predictor of later disordered eating in these  
26  
27 studies has always been disordered eating at the start of the study.<sup>8</sup> There is some  
28  
29 evidence for continuity between earlier feeding problems and later eating disorder  
30  
31 symptoms<sup>9</sup> and we are examining this systematically in this study. The GMS also  
32  
33 investigated the child's emotional and behavioural development, and social  
34  
35 communication skills. A topic of particular interest has been the development and  
36  
37 prevalence of repetitive behaviours, which are key behaviours in autistic spectrum  
38  
39 disorder but are also found in typically developing children. These repetitive  
40  
41 behaviours can range from repetitive motor mannerisms, intense special interests or  
42  
43 hobbies to more unusual sensory interests in the sight, taste, sound, smell or texture of  
44  
45 objects or people.<sup>10</sup> The GMS provided an opportunity to investigate prospectively  
46  
47 the relationship between various symptoms of psychopathology in typically  
48  
49 developing children, and to identify early risk and protective factors for both eating  
50  
51 problems and mental health disorders.  
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6 The second new area of interest was the high and rising rates of childhood obesity.<sup>11-13</sup>  
7  
8 It was known that body mass index (BMI; weight/height<sup>2</sup>) tracks through later  
9  
10 childhood into adulthood<sup>14</sup> and that teenage and adult obesity are associated with  
11  
12 increased health risks.<sup>15-18</sup> It was also suggested that low birth weight and subsequent  
13  
14 underweight in infancy are related to an increased risk of a number of chronic  
15  
16 diseases in adulthood, including obesity.<sup>19</sup> However, detailed normative data are  
17  
18 scarce and little was known about how lean and fat mass vary between individual  
19  
20 children and how far early weight gain is associated with early childhood fatness. In  
21  
22 addition, risk factors for early adiposity, such as dietary intake, physical activity and  
23  
24 sedentary behaviour, needed to be investigated. Finally, there was the potential for  
25  
26 intervention to reduce new cases of obesity in childhood. Evidence suggested that  
27  
28 family-based interventions offered potential for success in prevention of obesity,<sup>20</sup> yet  
29  
30 little information is available on what the content and approach of interventions  
31  
32 should be and which would be acceptable to families. The GMS was able to  
33  
34 investigate these issues when the cohort was aged 6-8 years.  
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44 The third new area of interest was the mechanisms by which early life exposures may  
45  
46 influence health in later life. It has been postulated that nutrition during pregnancy as  
47  
48 well as early feeding behaviours may alter mitotically heritable markings on DNA, so  
49  
50 called epigenetic markings, which can influence body composition and other  
51  
52 phenotypic characteristics in children through altering gene expression.<sup>21, 22</sup>  
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55  
56 Epigenetics provide a biologically plausible mechanism to explain developmental  
57  
58 programming and this area is currently the focus of much research activity. The GMS  
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2  
3 was able to investigate the association between early life exposure and epigenetic  
4 patterns in childhood when the cohort was aged 6-8 years.  
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### 10 **Who is in the sample?**

11  
12 The GMBS recruited participants shortly after birth in Gateshead, an urban district in  
13 north east England. All infants born to mothers resident in Gateshead in 34 pre-  
14 specified weeks between June 1999 and May 2000 were eligible. From the 1252  
15 eligible mothers, 1011 mothers joined the study; 116 (12%) were under 20 years of  
16 age, 518 (51%) were over 20 and under 30 and 377 (37%) were 30 or over. A total of  
17 1029 infants were recruited (18 sets of twins). Full details of recruitment are reported  
18 elsewhere.<sup>23</sup> The current GMS sample consists of any traceable survivor of the  
19 original cohort whose family have not asked to be withdrawn.  
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### 34 **How often have they been followed up?**

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36 The cohort was recruited by study researchers and baseline data were collected in an  
37 interview shortly after the baby was born. This was followed up by data collected by  
38 midwives at hospital discharge and six days, and by health visitors at ten days and  
39 three months. Parents were sent postal questionnaires at 6 weeks, and 4, 8, 12  
40 months. Families were invited to a clinic appointment at 13 months where the child  
41 and mother were measured for height and weight. A case-control study of children  
42 who failed to thrive had two lunchtime meals directly observed at 13-21 months.  
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53 There were further parent completed postal questionnaires at 30 months and 5-6 years.  
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60 A data sweep at age 6-8 years collected information from parents at home visits, and  
for the first time since 13 months children were assessed directly at school and/or  
home visits. At the 6-8 year data sweep parents were followed up with qualitative



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3 focus groups and one-to-one interviews. At 8-10 years data were collected data from  
4  
5 parents postally, and from children directly at school.  
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### 10 **What has been measured?**

11  
12 Descriptions of the data collected are shown in Table 1.  
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14

15  
16  
17 [Insert Table 1 about here]  
18  
19

20  
21  
22 Throughout infancy and early childhood detailed information was collected using  
23  
24 questionnaires completed by the child's carer, usually the mother. Characteristics  
25  
26 assessed included growth, feeding behaviour, temperament, illness and social  
27  
28 behaviour in children. Information about parent characteristics including eating  
29  
30 attitudes and depression was also collected. The GMBS mothers were given a special  
31  
32 edition of the Personal Child Health Record (PCHR) which is issued routinely to all  
33  
34 new mothers. The special edition PCHR included extra forms for health staff and  
35  
36 parents to record details about the child on the study's behalf; in particular mothers  
37  
38 were asked to get their baby weighed regularly and to transcribe the weights onto the  
39  
40 questionnaires they received and send them to the study office. The children and  
41  
42 parents were also measured directly at clinics run by study nurses at 13 months.  
43  
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45 School-entry child height and weight measurements were retrieved from NHS  
46  
47 records.  
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55 When the children were aged 5-6 years a postal questionnaire collected information  
56  
57 about the child's eating behaviour and maternal approach to feeding their child.  
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60 Information was also collected on the child's social communication skills, repetitive

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3 behaviours and common symptoms related to psychopathology, especially anxiety,  
4 emotional and conduct related symptoms.  
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10 When the children were aged 6-8 years information collected by parental  
11 questionnaire included the child's eating behaviour, the child's food and physical  
12 activity environment, parental eating characteristics and food intake, and socio-  
13 economic status. The children completed questionnaires on their food knowledge and  
14 eating behaviour. The child's dietary intake was observed, and physical activity  
15 levels and sedentary behaviour were measured using accelerometry. The children's  
16 and mothers' anthropometric measurements were taken as well as saliva samples for  
17 the purposes of DNA extraction and subsequent epigenetic analysis. After the  
18 quantitative data collection had finished, for parents who expressed an interest, views  
19 on childhood obesity were sought using focus groups and one-to-one interviews to  
20 explore knowledge, perceptions of childhood overweight and potential strategies for  
21 intervention.  
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41 A data sweep when the children were 8-10 years old took direct measures of  
42 children's habitual physical activity and sedentary behaviour (using accelerometry)  
43 and anthropometric measurements. Additionally, questionnaire data were collected  
44 from the children on their home environment, sports club activities and eating  
45 attitudes, and from parents on the children's home environment.  
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### 55 **What is attrition like?**

56  
57 The children have received a birthday card in the mail every year since birth with a  
58 letter including a reply slip for parents to return if they no longer wish to participate in  
59  
60

1  
2  
3 the research. Unless parents have let the study know that they would prefer not to be  
4  
5 contacted again, every effort is made to trace, contact and recruit the child for follow-  
6  
7 up data sweeps regardless of whether they remain in the area of birth or have  
8  
9 relocated. At the start of the 8-10 year data sweep two children were known to have  
10  
11 died and the parents of 161 children had asked to leave the study leaving a sample of  
12  
13 866 children eligible to be contacted.  
14  
15  
16  
17

18  
19  
20 Non-participation for individual data sweeps has been substantial, but different  
21  
22 families have participated in different data sweeps and consequently the study has  
23  
24 retraced and collected data from 697 families over the last 3 years.  
25  
26  
27

28  
29 The original sample was comparable to the northern region of England in terms of  
30  
31 socio-economic deprivation apart from slight under-representation of the most  
32  
33 affluent quintile, assessed using the Townsend deprivation index from the 1991  
34  
35 census (Table 2). Overall, non-participation has been higher in the least affluent  
36  
37 families than in the most affluent. Thus only 15% of families were in the most  
38  
39 affluent quintile at birth, but 70% of them participated up to 6-8 years; 19% were in  
40  
41 the least affluent quintile but only 56% participated at 6-8 years. This means that by  
42  
43 6-8 years the distribution across all the deprivation quintiles was fairly even (Table 2)  
44  
45 and the current sample is representative of the north of England. Non-participation  
46  
47 patterns according to maternal qualification are similar to the Townsend deprivation  
48  
49 index, with non-participation being higher in less educated mothers, particularly for  
50  
51 postal data sweeps (Table 2).  
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[Insert Table 2 about here]

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6 Tracing and tracking of the GMS children is ongoing and they are being flagged with  
7  
8 the UK National Health Service Central Register.  
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### 10 11 12 **What has it found? Key findings and publications**

#### 13 *Weight loss, weight gain and feeding in the first year of life*

14  
15  
16  
17 Postnatal weight loss was less than previous studies have shown. At five days, the  
18  
19 mean weight loss was 50g, only just over 1% below birth weight, and 3% of babies  
20  
21 were 10% below, none showing any signs of serious illness. One third had already  
22  
23 regained their birth weight.<sup>24</sup> More frequent feeding in the first week was related to  
24  
25 higher weight gain at 6 weeks of age for breast-feeders, but not for bottle-feeders.  
26  
27

28  
29 Babies who were fed by both breast and bottles were less likely to continue to be fed  
30  
31 by breast at 6 weeks of age than those who received only breast milk.<sup>25, 26</sup>  
32  
33

34  
35  
36 Nearly one quarter of the babies started eating solids before 3 months of age.

37  
38 Characteristics associated with early weaning were fast weight gain to 6 weeks, lower  
39  
40 socioeconomic status, parents' perceptions that their baby was hungry, and being  
41  
42 bottle fed. Babies weaned before 3 months, compared with those weaned after 4  
43  
44 months of age, had increased risk of diarrhoea.<sup>27</sup>  
45  
46  
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50  
51 Appetite at 6 weeks and 12 months was positively related to weight gain to 12  
52  
53 months, and encouraging a child to eat was associated with poorer weight gain.

54  
55 Children's appetite appeared to be related to how well or poorly they eat and grow.<sup>28</sup>  
56

57  
58 Mothers' characteristics such as their eating behaviour, mood, and social

59  
60 characteristics were not strongly associated with children's weight gain over the first

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3 year. Postnatal depression was associated with slower weight gain and increased rates  
4 of weight faltering in the infants up to 4 months, especially if they came from  
5  
6 deprived families, but by 12 months they were no different from the remainder of the  
7  
8 cohort.<sup>29</sup>  
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10

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15 Data from this cohort as well as the Avon Longitudinal Study of Parents and Children  
16  
17 (ALSPAC) have been used to assess how the growth of UK infants compares to  
18  
19 newly published WHO standards. Analysis showed that in both cohorts infants were  
20  
21 heavier than infants in the WHO growth study from about the age of 6 months but  
22  
23 showed very similar linear growth.<sup>30</sup>  
24  
25  
26  
27  
28

### 29 ***Mealtime energy intake and feeding behaviour***

30  
31 Video observations were used to identify types of feeding behaviour in children aged  
32  
33 13-21 months. Two meals were observed for each of 30 children who had shown  
34  
35 weight faltering in the first year and 57 controls. Energy intake and weight of food  
36  
37 eaten were also measured. The children who gained less weight were offered and  
38  
39 accepted food at the same rate as children with normal weight gain but had a lower  
40  
41 energy intake.<sup>31</sup>  
42  
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### 48 ***Diagnosis of borderline iron deficiency***

49  
50 This therapeutic trial included 462 infants whose parents agreed to have blood taken  
51  
52 and were successfully bled during the 13 month assessment. It explored how  
53  
54 successful five different blood markers were at identifying iron deficiency, as  
55  
56 indicated by a clear response to treatment. Low total and mean cell haemoglobins  
57  
58 proved good predictors of a response to treatment, but about half the children who  
59  
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3 responded had haemoglobins within the normal range. The three other markers were  
4  
5 only associated with a response when two or more were abnormal. Using the above  
6  
7 definition 13% of the children tested could be defined as truly iron deficient. These  
8  
9 children did not generally show differences in social factors or growth, apart from a  
10  
11 moderate association with breast feeding for over 4 months and a greatly increased  
12  
13 risk for a small minority of children from ultra orthodox Jewish families.<sup>32</sup>  
14  
15  
16  
17

### 18 19 20 *Eating behaviour and repetitive behaviours in toddlers and young children*

21  
22 Eating problems were perceived as common in toddlers and in the majority were  
23  
24 associated with normal growth, although weight faltering was more common in such  
25  
26 children. Excessive milk-drinking may have been a cause of low appetite at meal  
27  
28 times, but was not associated with poor growth.<sup>33</sup>  
29  
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31  
32

33  
34 Repetitive behaviours are an essential part of the diagnosis of autism but are also  
35  
36 commonly seen in typically developing children. Repetitive behaviours data from this  
37  
38 cohort, pooled with data from another local cohort, showed that 2 year old children  
39  
40 frequently engage in a range of different types of repetitive behaviours (with boys  
41  
42 showing higher scores than girls). These behaviours can be summarised within four  
43  
44 subscales: unusual sensory interests; repetitive motor movements; rigidity/adherence  
45  
46 to routine; and preoccupations with restricted patterns of interests. These study results  
47  
48 support the proposal that repetitive behaviours measured on subscales that closely  
49  
50 resemble the repetitive behaviour subtypes within the ICD-10 criteria for autism,  
51  
52 represent a continuum of functioning that extends to the typically developing child  
53  
54 population.<sup>10</sup> Subsequent analysis of new pooled data looking at the continuity of  
55  
56 repetitive behaviours from 2 years to 6 years shows that the predominant repetitive  
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1  
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3 behaviours change over time and that although the total rates of repetitive behaviours  
4  
5 reduce over time, they do not disappear.<sup>34</sup>  
6  
7

### 8 9 10 ***Surveillance of physical activity in the UK***

11  
12 Public health surveillance of physical activity in children in the UK has depended on a  
13  
14 parent-reported physical activity questionnaire which has not been validated. Physical  
15  
16 activity measured objectively using accelerometry in 6-7 year olds showed that levels  
17  
18 of habitual physical activity in children are likely to be substantially lower than those  
19  
20 reported in UK Health Surveys.<sup>35</sup>  
21  
22  
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### 27 ***Origins and perceptions of childhood adiposity***

28  
29 Parents' ability to identify whether their child was overweight was limited when  
30  
31 compared to current standards for overweight or obesity. Parents neither used nor  
32  
33 trusted current standards of childhood overweight and instead used alternative  
34  
35 approaches which heavily relied on extreme cases as a reference point.<sup>36, 37</sup>  
36  
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40

### 41 **What are the main strengths and weaknesses?**

42  
43 Gateshead has a stable population, but even so, maintaining up-to-date contact details  
44  
45 and keeping the families involved has been difficult. Direct contact has achieved  
46  
47 higher participation than postal contact. For example, 636 families returned postal  
48  
49 questionnaires at 12 months whereas 847 attended a clinic run by study nurses at 13  
50  
51 months. Using direct contact for retracing and data collection, the study has managed  
52  
53 to maintain a cohort of approximately 700 children.  
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3 Gateshead has a higher rate of deprivation than the rest of the northern region of  
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5  
6 England and this was reflected in the lower proportion of the most affluent families  
7  
8 recruited to the study. As is common for community based studies, there has been  
9  
10 higher rates of attrition among the most deprived families.<sup>38, 39</sup> However, due to  
11  
12 higher retention of the most affluent families compared to the least affluent families,  
13  
14 the current sample is socially diverse and representative of the north of England.  
15  
16  
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19  
20 The cohort has the benefit of a wealth of data on maternal characteristics and the  
21  
22 child's early eating patterns, developmental psychopathology, dietary intake at 6-8  
23  
24 years, a comprehensive set of body composition measurements, lifestyle behaviours  
25  
26 and physical activity at 6-8 and 8-10 years, and DNA samples. It will provide crucial  
27  
28 information for investigation of both physical and mental health. Of obvious  
29  
30 importance is the examination of the role of fast weight gain in infancy and childhood  
31  
32 lifestyle behaviours in the development of later obesity and other chronic disease  
33  
34 outcomes in later life. A cohort of this size is only adequately powered to examine  
35  
36 variation within the normal range and between major subgroups, but since our current  
37  
38 main area of interest, childhood obesity, is now so common, the study is likely to be  
39  
40 adequately powered to examine important risk factors.  
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#### 49 **Can I get hold of the data? Where can I find out more?**

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51 Most of the data are currently being actively analysed by the existing study team, but  
52  
53 we welcome suggestions for collaboration. Potential collaborators should contact  
54  
55 Professor Ashley Adamson at the Institute of Health and Society at Newcastle  
56  
57 University. The study has a website at <http://www.research.ncl.ac.uk/gms/>.  
58  
59  
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## Contributor's list

Dr Kathryn Parkinson contributed to protocol development, and was responsible for co-ordination of the study and writing the manuscript.

Dr Mark Pearce contributed to protocol development and writing the manuscript, and was responsible for the analytical framework and supervision of data analysis.

Dr Anne Dale maintained liaison with Gateshead Children's Services, and contributed to protocol development and writing the manuscript.

Dr Robert Drewett contributed to protocol development and writing the manuscript.

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3 Dr Paul McArdle contributed to protocol development and writing the manuscript.  
4

5 Professor Charlotte Wright founded the GMBS cohort and was responsible for  
6 execution of the GMBS study, and contributed to protocol development and writing  
7 the manuscript.  
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10 Professor Ann Le Couteur was responsible for execution of the 5-6 year datasweep,  
11 and contributed to protocol development and writing the manuscript.  
12

13 Dr Caroline Relton was responsible for execution of the epigenetic element of the  
14 study and contributed to the writing the manuscript.  
15  
16

17 Professor Ashley Adamson had primary responsibility for execution of the GMS  
18 datasweeps, and contributed to protocol development and writing the manuscript.  
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### 22 **Conflict of interest**

23 The authors declare no conflict of interest.  
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**Table 1. Summary of data collected since birth (n=1029 children)**

Cohort age	Where	By whom	Number of participants (%)	Data collected
After birth	Hospital/home	Mother	1029 (100%)	Birth weight Milk feeding behaviour * Mode of milk feeding Socio-economic status**
Day 3	Hospital	Midwife	633 (62%)	Feeding ratings**
Day 6	Hospital/home	Midwife	801 (78%)	Feeding ratings**
Day 10	Home	Health visitor	944 (92%)	Feeding ratings**
6 weeks	Home	Parent	832 (80%)	Milk feeding behaviour * Cessation of breast feeding, weaning etc* Illness** Infant temperament <sup>40</sup> † Weights (from Personal Child Health Record (PCHR))
3 months	Home	Health visitor	792 (77%)	Feeding ratings** Maternal depression <sup>41</sup>
4 months	Home	Parent	762 (74%)	Milk feeding behaviour * Cessation of breast feeding, weaning etc* Illness** Accidents** Adverse family life events <sup>42, 43</sup> Weights (from PCHR)
8 months	Home	Parent	675 (65%)	Solid feeding behaviour * Cessation of breast feeding, weaning etc* Illness** Accidents** Infant temperament <sup>40</sup> Weights (from PCHR)
12 months	Home	Parent	636 (61%)	Solid feeding behaviour * Cessation of breast feeding General behaviour** Illness** Accidents** Maternal eating behaviour <sup>44</sup> Maternal childhood <sup>45</sup> Weights (from PCHR)
13 months	Clinic	Study nurse	847 (82%)	Child's height and weight (measured) Blood for full blood count, ferritin, zinc protoporphyrin Mother's height and weight (measured)
30 months	Home	Parent	492 (47%)	General feeding ** Food preferences <sup>46 47</sup> Drinks** General behaviour** Repetitive Behaviour Questionnaire <sup>48, 49</sup> Difficulties with child** Illness** Weights (from PCHR)
4-5 years	School	School nurse	724 (70%)	Child's height and weight (measured)
5-6 years	Home	Parent	506 (49%)	Child's height and weight (measured) Mother's height and weight (measured) Child's appetite, mealtimes, problems ** General child health and education ** Mother's approach to feeding her child <sup>50</sup> Child's eating behaviour <sup>51</sup> Repetitive Behaviour Questionnaire <sup>48, 49</sup> Common symptoms of psychopathology <sup>52</sup> Social communication problems <sup>53</sup> Parental employment (self-coded method) <sup>54</sup> Socio-economic status**

6-8 years	Home	Parent	617 (60%)	Child's eating behaviour ** Child's risk factors for eating disorders <sup>55</sup> Child's food environment <sup>56</sup> Child physical activity environment ** Parental concern about child's obesity in adulthood <sup>57</sup> Parental perception of child's body shape <sup>58, 59</sup> Parental perception of child's activity <sup>60</sup> § Parent's attitudes and knowledge about food <sup>61-63</sup> Maternal eating behaviour <sup>44</sup> Parent's physical activity <sup>64</sup> Parent food frequency <sup>65</sup> Family health status ** Parental employment (self-coded method) <sup>54</sup> Socio-economic status ** Parents' body measurements; height, weight, waist, hip, bioelectrical impedance
			488 (47%)	DNA biomarkers (saliva sample)
6-8 years	School	Teacher	576 (56%)	Common symptoms of psychopathology <sup>52</sup>
6-8 years	School	Child	619 (60%)	Attitudes and knowledge about food <sup>62</sup> Restrained eating <sup>66</sup> Body image <sup>59</sup> Habitual physical activity (accelerometry) <sup>67</sup> Habitual sedentary behaviour (accelerometry) <sup>67</sup> Body measurements; height, weight, waist, skinfolds (biceps, triceps, subscapular and supra-iliac), bone frame (knee, wrist, shoulders, hips and elbow) and bioelectrical impedance
			543 (53%)	DNA biomarkers (saliva sample)
6-8 years	Home and school	Parents and observers	486 (47%)	Child's food intake over 4 days <sup>68</sup>
6-8 years	Community premises	Parents and interviewers (Qualitative study)	37 16	Parent focus groups on childhood obesity Parent one-to-one interviews on childhood obesity
8-10 years	Home	Parent	495 (48%)	Child's sedentary opportunities in the home <sup>69</sup>
8-10 years	School	Child	590 (57%)	Habitual physical activity (accelerometry) <sup>67</sup> Habitual sedentary behaviour (accelerometry) <sup>67</sup> Sports activity and how they feel physically <sup>70, 71</sup> Sedentary opportunities in the home <sup>69</sup> Eating patterns <sup>72</sup> and appetite * Body image <sup>59</sup> Body measurements; height, weight, waist, and bioelectrical impedance

\* Influenced by previous work <sup>73</sup> or developed for the GMS

\*\* Items developed for the GMS

\*\*\* Non-validated, based on previous work

† Items relevant to six week infants used

§ Interviewer led

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For Review Only

Table 2. Socio-economic characteristics of mothers (based on data collected at birth)

	Baseline		12 months		13 month health check		30 months		5-6 years		6-8 years		8-10 years	
	N=1011		N=624		N=830		N=482		N=495		N=605		N=576	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
<b>Townsend quintile*</b>														
1 (most affluent)	156	15	129	21	137	17	110	23	102	21	109	18	103	18
2	204	20	146	23	178	21	111	23	113	23	129	21	124	22
3	227	23	140	22	189	23	107	22	115	23	135	22	128	22
4	226	22	121	19	177	21	88	18	85	17	118	20	114	20
5 (least affluent)	192	19	83	13	143	17	61	13	75	15	108	18	101	18
Missing	6	1	5	1	6	1	5	1	5	1	6	1	6	1
<b>Qualification</b>														
A levels or above	243	24	186	30	213	26	150	31	159	32	175	29	167	29
GCSEs or equivalent	495	49	325	52	415	50	255	53	246	50	295	49	273	47
NVQ's or none	194	19	83	13	144	17	55	11	61	12	98	16	99	17
Missing	79	8	30	5	58	7	22	5	29	6	37	6	37	6

Percentages do not add up to 100 in all cases due to rounding

\* Based on Townsend deprivation index from 1991 census, using enumeration districts as the unit of analysis with the Northern Region of England as the population for comparison for the calculation of the quintiles

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For Review Only

**Cohort Profile: The Gateshead Millennium Study**

Kathryn N Parkinson<sup>a</sup>, Mark S Pearce<sup>b</sup>, Anne Dale<sup>c</sup>, John J Reilly<sup>d</sup>, Robert F  
Drewett<sup>e</sup>, Charlotte M Wright<sup>f</sup>, Caroline L Relton<sup>g</sup>, Paul McArdle<sup>h</sup>, Ann S Le  
Couteur<sup>b</sup>, Ashley J Adamson<sup>a</sup>

Institute of Health and Society<sup>a</sup>, Human Nutrition Research Centre, William Leech  
Building, Framlington Place, Newcastle University, Newcastle upon Tyne, NE2 4HH,  
UK

Deleted: 1st Floor

Institute of Health and Society<sup>b</sup>, Newcastle University, Sir James Spence Institute of  
Child Health, Royal Victoria Infirmary, Newcastle upon Tyne, NE1 4LP, UK

Gateshead Health NHS Foundation Trust, Children's Department<sup>c</sup>, Queen Elizabeth  
Avenue, Sheriff Hill, Queen Elizabeth Hospital, Gateshead, NE9 6SX, UK

Division of Developmental Medicine<sup>d</sup>, University of Glasgow, Faculty of Medicine,  
Queen Mother's Tower, Yorkhill Hospitals, Glasgow, G3 8SJ, UK

Department of Psychology<sup>e</sup>, Science Laboratories, South Road, Durham University,  
Durham, DH1 3LE, UK

PEACH Unit<sup>f</sup>, University of Glasgow, Faculty of Medicine, Queen Mother's Tower,  
Yorkhill Hospitals, Glasgow, G3 8SJ, UK

1  
2 Institute of Ageing and Health<sup>g</sup>, Newcastle University, Sir James Spence Institute of  
3  
4 Child Health, Royal Victoria Infirmary, Newcastle upon Tyne, NE1 4LP, UK  
5  
6

7  
8 Northumberland, Tyne & Wear NHS Trust<sup>h</sup>, Child and Adolescent Mental Health,  
9  
10 Burdon Terrace, Jesmond, Fleming Nuffield Unit, Newcastle upon Tyne, NE2 3AE,  
11  
12 UK  
13

14  
15  
16 <sup>a</sup>Corresponding author:

17  
18 Dr Kathryn Parkinson, Institute of Health and Society, Human Nutrition Research  
19  
20 Centre, Room M1 151, 1st Floor William Leech Building, Framlington Place,  
21  
22 Newcastle University, Newcastle upon Tyne, NE2 4HH, UK.  
23  
24 Tel: (0191) 2223828 Fax: (0191) 2225581 Email: kathryn.parkinson@ncl.ac.uk  
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29 **Key messages**

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31 The Gateshead Millennium Study recruited a socially diverse birth cohort in  
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33 1999/2000. The current sample is representative of the north of England.

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36 The cohort provides a rich dataset on children's early eating characteristics, dietary  
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38 intake, physical activity, and developmental psychopathology.

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43 The study will allow examination of the development of childhood obesity, and the  
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45 development of preventative strategies.

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49 **Word count:** 3315 (main body of paper, ie excluding title page, contributor's list,  
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51 references and tables)  
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### How did the study come about?

The Gateshead Millennium Baby Study (GMBS) originated from the observation that slower than expected weight gain in infancy, traditionally known as failure to thrive, but more recently as 'weight faltering', had never been satisfactorily explained. There were methodological problems associated with much previous research. The first was the use of attained weight criteria to identify slow weight gain in infancy, which confounds poor postnatal weight gain with poor prenatal weight gain. The second was the use of referred samples of children, leading to selection biases. The third was the use of retrospective accounts from parents after poor weight gain had already been identified. The GMBS was thus originally designed to investigate the antecedents of weight faltering in a population based prospective study which addressed the main methodological problems of previous research.

### What does it cover?

The original GMBS set out to examine infant feeding behaviour and relate it to subsequent weight gain and weight faltering. It also investigated risk factors for iron deficiency in infancy. Relevant maternal characteristics including feeding style, eating attitudes and depression were also examined. More recently the title of the study has been changed to Gateshead Millennium Study (GMS) to reflect the age of the cohort. The study has continued to focus on feeding and growth, with three additional areas of interest emerging.

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**Deleted:** during the early feeding period and relate it to subsequent weight gain and weight faltering.

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First, it investigated aspects of developmental psychopathology using measurements principally taken at 5-6 years of age. A recent UK prevalence survey in 5-19 year olds reported that mental health disorders are common, affecting approximately 8%

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and that sub-threshold symptoms were even more common.<sup>1</sup> Eating disorders comprise an important social and medical problem developing over late childhood. Accurate figures on the prevalence of eating disorders have not been easy to establish. Those in a recent comprehensive review suggest a prevalence of 0.28% for anorexia nervosa, 1% for bulimia nervosa, 1.5% for night eating syndrome and 2.3% for binge eating disorder.<sup>2-4</sup> A much higher proportion of young women report less specifically diagnosable problems such as occasional binge eating or self induced vomiting or score high on tests of abnormal eating attitudes.<sup>5</sup> There is also evidence that sub-threshold eating disorders are commonly associated with depression in adolescents, and there is a strong link between restrictive eating and aggression, attempted suicide and substance misuse.<sup>6,7</sup> Most longitudinal studies of disordered eating have started in the teenage years, but the strongest predictor of later disordered eating in these studies has always been disordered eating at the start of the study.<sup>8</sup> There is some evidence for continuity between earlier feeding problems and later eating disorder symptoms<sup>9</sup> and we are examining this systematically in this study. The GMS also investigated the child's emotional and behavioural development, and social communication skills. A topic of particular interest has been the development and prevalence of repetitive behaviours, which are key behaviours in autistic spectrum disorder but are also found in typically developing children. These repetitive behaviours can range from repetitive motor mannerisms, intense special interests or hobbies to more unusual sensory interests in the sight, taste, sound, smell or texture of objects or people.<sup>10</sup> The GMS provided an opportunity to investigate prospectively the relationship between various symptoms of psychopathology in typically developing children, and to identify early risk and protective factors for both eating problems and mental health disorders.

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The second new area of interest was the high and rising rates of childhood obesity.<sup>11-13</sup>

It was known that body mass index (BMI; weight/height<sup>2</sup>) tracks through later childhood into adulthood<sup>14</sup> and that teenage and adult obesity are associated with increased health risks.<sup>15-18</sup> It was also suggested that low birth weight and subsequent underweight in infancy are related to an increased risk of a number of chronic diseases in adulthood, including obesity.<sup>19</sup> However, detailed normative data are scarce and little was known about how lean and fat mass vary between individual children and how far early weight gain is associated with early childhood fatness. In addition, risk factors for early adiposity, such as dietary intake, physical activity and sedentary behaviour, needed to be investigated. Finally, there was the potential for intervention to reduce new cases of obesity in childhood. Evidence suggested that family-based interventions offered potential for success in prevention of obesity,<sup>20</sup> yet little information is available on what the content and approach of interventions should be and which would be acceptable to families. The GMS was able to investigate these issues when the cohort was aged 6-8 years.

**Deleted:** s, behaviours (including repetitive behaviours) and social communication skills as well as eating behaviours. This information in combination with the early infant and maternal behaviour measures allows us to study the continuities and discontinuities of particular behaviours (such as repetitive behaviours) in a normally developing sample of children, identify early predictors of later onset disorders and consider prospectively potential risk and protective factors for child mental health problems<sup>1</sup> including persistent disordered eating behaviours in later childhood. The incidence of eating disorders is reported to rise steeply over the peri-pubertal period, so most longitudinal studies have started in the teenage years. However, in longitudinal studies the strongest predictor of later disordered eating has always been disordered eating at the start of the study.<sup>2</sup> There is evidence that there are early infant predictors of later eating disorder symptoms.<sup>3</sup> It has also been shown that some problems such as persistent binge eating are specifically associated with the development of obesity.<sup>4</sup> Eating problems are common in early childhood but may pose particular management problems for certain at risk groups such as those with autism/autism spectrum disorders<sup>5</sup> or other additional physical or mental health problems. The GMS therefore provided an opportunity to investigate prospectively the relationship between various symptoms of psychopathology and eating and weight problems.<sup>¶</sup>

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The third new area of interest was the mechanisms by which early life exposures may influence health in later life. It has been postulated that nutrition during pregnancy as well as early feeding behaviours may alter mitotically heritable markings on DNA, so called epigenetic markings, which can influence body composition and other phenotypic characteristics in children through altering gene expression.<sup>21, 22</sup> Epigenetics provide a biologically plausible mechanism to explain developmental programming and this area is currently the focus of much research activity. The GMS

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was able to investigate the association between early life exposure and epigenetic patterns in childhood, when the cohort was aged 6-8 years.

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### Who is in the sample?

The GMBS recruited participants shortly after birth in Gateshead, an urban district in north east England. All infants born to mothers resident in Gateshead in 34 pre-specified weeks between June 1999 and May 2000 were eligible. From the 1252 eligible mothers, 1011 mothers joined the study; 116 (12%) were under 20 years of age, 518 (51%) were over 20 and under 30 and 377 (37%) were 30 or over. A total of 1029 infants were recruited (18 sets of twins). Full details of recruitment are reported elsewhere.<sup>23</sup> The current GMS sample consists of any traceable survivor of the original cohort whose family have not asked to be withdrawn.

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Deleted: At the most recent completed follow-up, 619 children took part.<sup>¶</sup>

### How often have they been followed up?

The cohort was recruited by study researchers and baseline data were collected in an interview shortly after the baby was born. This was followed up by data collected by midwives at hospital discharge and six days, and by health visitors at ten days and three months. Parents were sent postal questionnaires at 6 weeks, and 4, 8, 12 months. Families were invited to a clinic appointment at 13 months where the child and mother were measured for height and weight. A case-control study of children who failed to thrive had two lunchtime meals directly observed at 13-21 months.

There were further parent completed postal questionnaires at 30 months and 5-6 years.

A data sweep at age 6-8 years collected information from parents at home visits, and

for the first time since 13 months children were assessed directly at school and/or home visits. At the 6-8 year data sweep parents were followed up with qualitative

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focus groups and one-to-one interviews, At 8-10 years data were collected data from parents postally, and from children directly at school.

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**Deleted:** The latest data sweep at 8-10 years is collecting

**Deleted:** on objectively measured habitual physical activity and sedentary behaviour, body measurements and eating attitudes.¶

### What has been measured?

Descriptions of the data collected are shown in Table 1.

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[Insert Table 1 about here]

Throughout infancy and early childhood detailed information was collected using questionnaires completed by the child's carer, usually the mother. Characteristics assessed included growth, feeding behaviour, temperament, illness and social behaviour in children. Information about parent characteristics including eating attitudes and depression was also collected. The GMBS mothers were given a special edition of the Personal Child Health Record (PCHR) which is issued routinely to all new mothers. The special edition PCHR included extra forms for health staff and parents to record details about the child on the study's behalf; in particular mothers were asked to get their baby weighed regularly and to transcribe the weights onto the questionnaires they received and send them to the study office. The children and parents were also measured directly at clinics run by study nurses at 13 months.

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School-entry child height and weight measurements were retrieved from NHS records.

When the children were aged 5-6 years a postal questionnaire collected information about the child's eating behaviour and maternal approach to feeding their child.

Information was also collected on the child's social communication skills, repetitive

behaviours and common symptoms related to psychopathology, especially anxiety, emotional and conduct related symptoms.

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When the children were aged 6-8 years information collected by parental questionnaire included the child's eating behaviour, the child's food and physical activity environment, parental eating characteristics and food intake, and socio-

economic status. The children completed questionnaires on their food knowledge and eating behaviour. The child's dietary intake was observed, and physical activity levels and sedentary behaviour were measured using accelerometry. The children's and mothers' anthropometric measurements were taken as well as saliva samples for the purposes of DNA extraction and subsequent epigenetic analysis. After the quantitative data collection had finished, for parents who expressed an interest, views on childhood obesity were sought using focus groups and one-to-one interviews to explore knowledge, perceptions of childhood overweight and potential strategies for intervention.

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A data sweep when the children were 8-10 years old took direct measures of children's habitual physical activity and sedentary behaviour (using accelerometry) and anthropometric measurements. Additionally, questionnaire data were collected from the children on their home environment, sports club activities and eating attitudes, and from parents on the children's home environment.

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**What is attrition like?**

The children have received a birthday card in the mail every year since birth with a letter including a reply slip for parents to return if they no longer wish to participate in

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the research. Unless parents have let the study know that they would prefer not to be contacted again, every effort is made to trace, contact and recruit the child for follow-up data sweeps regardless of whether they remain in the area of birth or have relocated. At the start of the 8-10 year data sweep two children were known to have died and the parents of 161 children had asked to leave the study leaving a sample of 866 children eligible to be contacted.

Non-participation for individual data sweeps has been substantial, but different families have participated in different data sweeps and consequently the study has retraced and collected data from 697 families over the last 3 years.

The original sample was comparable to the northern region of England in terms of

socio-economic deprivation apart from slight under-representation of the most affluent quintile, assessed using the Townsend deprivation index from the 1991

census (Table 2). Overall, non-participation has been higher in the least affluent

families than in the most affluent. Thus only 15% of families were in the most affluent quintile at birth, but 70% of them participated up to 6-8 years; 19% were in the least affluent quintile but only 56% participated at 6-8 years. This means that by 6-8 years the distribution across all the deprivation quintiles was fairly even (Table 2) and the current sample is representative of the north of England. Non-participation patterns according to maternal qualification are similar to the Townsend deprivation index, with non-participation being higher in less educated mothers, particularly for postal data sweeps (Table 2).

[Insert Table 2 about here]

**Deleted:** Of the 1270 births eligible for recruitment, 1029 (82%) were recruited to 1011 mothers (18 sets of twins). The recruited sample

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Tracing and tracking of the GMS children is ongoing and they are being flagged with the UK National Health Service Central Register.

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[Insert Table 2 about here]¶

**What has it found? Key findings and publications**

Weight loss, weight gain and feeding in the first year of life

Postnatal weight loss was less than previous studies have shown. At five days, the mean weight loss was 50g, only just over 1% below birth weight, and 3% of babies were 10% below, none showing any signs of serious illness. One third had already regained their birth weight.<sup>24</sup> More frequent feeding in the first week was related to higher weight gain at 6 weeks of age for breast-feeders, but not for bottle-feeders. Babies who were fed by both breast and bottles were less likely to continue to be fed by breast at 6 weeks of age than those who received only breast milk.<sup>25, 26</sup>

**Deleted:** Postal questionnaire data were collected on 832 infants at 6 weeks (80%), 762 at 4 months (74%), 675 at 8 months (65%), 636 at 12 months (61%), 492 (47%) at 30 months and 506 (49%) at 5-6 years. Child and mother weights and heights at 13 months were obtained for 848 families (82%) by GMBS research nurses. Child weights and heights were retrieved from NHS records at school entry for 724 children (70%). Further postal questionnaire data were collected on 506 children at 5-6 years (49%).¶

¶ At the start of the 6-8 year data sweep in 2006 two children were known to have died and the parents of 99 children had asked to leave the study leaving an eligible sample of 928 children. From these 928 children and their families, data were collected from 619 children (66%) at school and/or home visits. 488 (79%) of mothers and 543 (88%) of children provided saliva samples for DNA extraction. At 6-8 years there were still substantial numbers in all quintiles of deprivation (see Table 2).¶ The children have received a birthday card in the mail every year since birth with a letter including a reply slip for parents to return if they no longer wish to participate in the research. Unless parents have let the study know that they would prefer not to be contacted again, every effort is made to trace, contact and recruit the child for follow-up data sweeps regardless of whether they remain in the area of birth or have relocated elsewhere.

Nearly one quarter of the babies started eating solids before 3 months of age.

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Characteristics associated with early weaning were fast weight gain to 6 weeks, lower socioeconomic status, parents' perceptions that their baby was hungry, and being bottle fed. Babies weaned before 3 months, compared with those weaned after 4 months of age, had increased risk of diarrhoea.<sup>27</sup>

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**Deleted:** Only 26 babies lost more than 10% of their weight, none showing any signs of serious illness.

Appetite at 6 weeks and 12 months was positively related to weight gain to 12 months, and encouraging a child to eat was associated with poorer weight gain.

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¶ Early feeding patterns and weaning¶

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Children's appetite appeared to be related to how well or poorly they eat and grow.<sup>28</sup>

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Mothers' characteristics such as their eating behaviour, mood, and social characteristics were not strongly associated with children's weight gain over the first

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year. Postnatal depression was associated with slower weight gain and increased rates of weight faltering in the infants up to 4 months, especially if they came from deprived families, but by 12 months they were no different from the remainder of the cohort.<sup>29</sup>

Data from this cohort as well as the Avon Longitudinal Study of Parents and Children (ALSPAC) have been used to assess how the growth of UK infants compares to newly published WHO standards. Analysis showed that in both cohorts infants were heavier than infants in the WHO growth study from about the age of 6 months but showed very similar linear growth.<sup>30</sup>

### *Mealtime energy intake and feeding behaviour*

Video observations were used to identify types of feeding behaviour in children aged 13-21 months. Two meals were observed for each of 30 children who had shown weight faltering in the first year and 57 controls. Energy intake and weight of food eaten were also measured. The children who gained less weight were offered and accepted food at the same rate as children with normal weight gain but had a lower energy intake.<sup>31</sup>

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### *Diagnosis of borderline iron deficiency*

This therapeutic trial included 462 infants whose parents agreed to have blood taken and were successfully bled during the 13 month assessment. It explored how successful five different blood markers were at identifying iron deficiency, as indicated by a clear response to treatment. Low total and mean cell haemoglobins proved good predictors of a response to treatment, but about half the children who



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responded had haemoglobins within the normal range. The three other markers were only associated with a response when two or more were abnormal. Using the above definition 13% of the children tested could be defined as truly iron deficient. These children did not generally show differences in social factors or growth, apart from a moderate association with breast feeding for over 4 months and a greatly increased risk for a small minority of children from ultra orthodox Jewish families.<sup>32</sup>

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Eating behaviour and repetitive behaviours in toddlers and young children

Eating problems were perceived as common in toddlers and in the majority were associated with normal growth, although weight faltering was more common in such children. Excessive milk-drinking may have been a cause of low appetite at meal times, but was not associated with poor growth.<sup>33</sup>

Deleted: Growth compared to International WHO standards¶  
Data from this cohort as well as the ALSPAC cohort have been used to assess how the growth of UK infants compares to newly published WHO standards. Analysis showed that in both cohorts infants were relatively heavier than infants in the WHO growth study from about the age of 6 months but showed very similar linear growth.<sup>25</sup>¶

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Repetitive behaviours are an essential part of the diagnosis of autism but are also commonly seen in typically developing children. Repetitive behaviours data from this cohort, pooled with data from another local cohort, showed that 2 year old children frequently engage in a range of different types of repetitive behaviours (with boys showing higher scores than girls). These behaviours can be summarised within four subscales: unusual sensory interests; repetitive motor movements; rigidity/adherence to routine; and preoccupations with restricted patterns of interests. These study results support the proposal that repetitive behaviours measured on subscales that closely resemble the repetitive behaviour subtypes within the ICD-10 criteria for autism, represent a continuum of functioning that extends to the typically developing child population.<sup>10</sup> Subsequent analysis of new pooled data looking at the continuity of repetitive behaviours from 2 years to 6 years shows that the predominant repetitive

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2 behaviours change over time and that although the total rates of repetitive behaviours  
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4 reduce over time, they do not disappear.<sup>34</sup>  
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### 7 8 ***Surveillance of physical activity in the UK*** 9

10 Public health surveillance of physical activity in children in the UK has depended on a  
11 parent-reported physical activity questionnaire which has not been validated. Physical  
12 activity measured objectively using accelerometry in 6-7 year olds showed that levels  
13 of habitual physical activity in children are likely to be substantially lower than those  
14 reported in UK Health Surveys.<sup>35</sup>  
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### 19 20 ***Origins and perceptions of childhood adiposity*** 21

22 Parents' ability to identify whether their child was overweight was limited when  
23 compared to current standards for overweight or obesity. Parents neither used nor  
24 trusted current standards of childhood overweight and instead used alternative  
25 approaches which heavily relied on extreme cases as a reference point.<sup>36, 37</sup>  
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### 33 34 **What are the main strengths and weaknesses?** 35

36 Gateshead has a stable population, but even so, maintaining up-to-date contact details  
37 and keeping the families involved has been difficult. Direct contact has achieved  
38 higher participation than postal contact. For example, 636 families returned postal  
39 questionnaires at 12 months whereas 847 attended a clinic run by study nurses at 13  
40 months. Using direct contact for retracing and data collection, the study has managed  
41 to maintain a cohort of approximately 700 children.  
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Gateshead has a higher rate of deprivation than the rest of the northern region of England and this was reflected in the lower proportion of the most affluent families recruited to the study. As is common for community based studies, there has been higher rates of attrition among the most deprived families.<sup>38,39</sup> However, due to higher retention of the most affluent families compared to the least affluent families, the current sample is socially diverse and representative of the north of England.

The cohort has the benefit of a wealth of data on maternal characteristics and the child's early eating patterns, developmental psychopathology, dietary intake at 6-8 years, a comprehensive set of body composition measurements, lifestyle behaviours and physical activity at 6-8 and 8-10 years, and DNA samples. It will provide crucial information for investigation of both physical and mental health. Of obvious importance is the examination of the role of fast weight gain in infancy and childhood lifestyle behaviours in the development of later obesity and other chronic disease outcomes in later life. A cohort of this size is only adequately powered to examine variation within the normal range and between major subgroups, but since our current main area of interest, childhood obesity, is now so common, the study is likely to be adequately powered to examine important risk factors.

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

Most of the data are currently being actively analysed by the existing study team, but we welcome suggestions for collaboration. Potential collaborators should contact

Professor Ashley Adamson at the Institute of Health and Society at Newcastle University. The study has a website at <http://www.research.ncl.ac.uk/gms/>.

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The cohort is socially diverse and representative of contemporary UK children. Gateshead has a stable population, but even so, keeping in touch with families is a major challenge. Maintaining up-to-date contact details and keeping the families involved has been difficult, with direct contact being more successful than postal contact. Support from health professionals, telephone reminders, media involvement, birthday cards and newsletters helped the success of the study.¶

¶ Gateshead has a higher rate of deprivation than the rest of the northern region of England and this was reflected in the lower proportion of the most affluent families recruited to the study. However 69% of the most affluent families have been retained from birth to 6-8 years compared with 55% of the least affluent families. The cohort has the benefit of a wealth of data about the child's early eating patterns and maternal characteristics from birth, parental reports of eating patterns, social communication skills and a range of behaviours at 5-8 years, dietary intake at 6-8 years, a comprehensive set of body composition measurements and lifestyle behaviours at 6-8 years, longitudinal data on physical activity at 6-8 and 8-10 years, and DNA samples. It will also provide crucial information for future investigation of both physical and mental health. Of obvious importance is the examination of the role of fast weight gain in infancy and childhood lifestyle behaviours in the development of later obesity.¶

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## Acknowledgements

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### Contributor's list

Dr Kathryn Parkinson contributed to protocol development, and was responsible for co-ordination of the study and writing the manuscript.

Dr Mark Pearce contributed to protocol development and writing the manuscript, and was responsible for the analytical framework and supervision of data analysis.

Dr Anne Dale maintained liaison with Gateshead Children's Services, and contributed to protocol development and writing the manuscript.

Dr Robert Drewett contributed to protocol development and writing the manuscript.

1  
2 Dr Paul McArdle contributed to protocol development and writing the manuscript.

3  
4 Professor Charlotte Wright founded the GMBS cohort and was responsible for  
5  
6 execution of the GMBS study, and contributed to protocol development and writing  
7  
8 the manuscript.

9  
10 Professor Ann Le Couteur was responsible for execution of the 5-6 year datasweep,  
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12 and contributed to protocol development and writing the manuscript.

13  
14 Dr Caroline Relton was responsible for execution of the epigenetic element of the  
15  
16 study and contributed to the writing the manuscript.

17  
18 Professor Ashley Adamson had primary responsibility for execution of the GMS  
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20 datasweeps, and contributed to protocol development and writing the manuscript.

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24 **Conflict of interest**

25  
26  
27 The authors declare no conflict of interest.  
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**Table 1. Summary of data collected since birth (n=1029 children)**

Cohort age	Where	By whom	Number of participants (%)	Data collected	
After birth	Hospital/home	Mother	1029 (100%)	Birth weight Milk feeding behaviour* Mode of milk feeding Socio-economic status**	Deleted: Core m Deleted: questions Deleted: questions
Day 3	Hospital	Midwife	633 (62%)	Feeding ratings**	Deleted: questions
Day 6	Hospital/home	Midwife	801 (78%)	Feeding ratings**	
Day 10	Home	Health visitor	944 (92%)	Feeding ratings**	
6 weeks	Home	Parent	832 (80%)	Milk feeding behaviour* Cessation of breast feeding, weaning etc* Illness** Infant temperament <sup>40</sup> † Weights (from Personal Child Health Record (PCHR))	Deleted: Core m Deleted: questions Deleted: Question concerning c
3 months	Home	Health visitor	792 (77%)	Feeding ratings** Maternal depression <sup>41</sup>	
4 months	Home	Parent	762 (74%)	Milk feeding behaviour* Cessation of breast feeding, weaning etc* Illness** Accidents** Adverse family life events <sup>42,43</sup> Weights (from PCHR)	Deleted: Core m Deleted: questions Deleted: Question concerning c
8 months	Home	Parent	675 (65%)	Solid feeding behaviour* Cessation of breast feeding, weaning etc* Illness** Accidents** Infant temperament <sup>40</sup> Weights (from PCHR)	Deleted: Core s Deleted: questions Deleted: Question concerning c
12 months	Home	Parent	636 (61%)	Solid feeding behaviour* Cessation of breast feeding General behaviour* Illness** Accidents** Maternal eating behaviour <sup>44</sup> Maternal childhood <sup>45</sup> Weights (from PCHR)	Deleted: Core s Deleted: questions Deleted: Question concerning c
13 months	Clinic	Study nurse	847 (82%)	Child's height and weight (measured) Blood for full blood count, ferritin, zinc protoporphyrin Mother's height and weight (measured)	Deleted: 8
30 months	Home	Parent	492 (47%)	General feeding** Food preferences <sup>46,47</sup> Drinks** General behaviour** Repetitive Behaviour Questionnaire <sup>48,49</sup> Difficulties with child** Illness** Weights (from PCHR)	Deleted: questions
4-5 years	School	School nurse	724 (70%)	Child's height and weight (measured)	
5-6 years	Home	Parent	506 (49%)	Child's height and weight (measured) Mother's height and weight (measured) Child's appetite, mealtimes, problems** General child health and education** Mother's approach to feeding her child <sup>50</sup> Child's eating behaviour <sup>51</sup> Repetitive Behaviour Questionnaire <sup>48,49</sup> Common symptoms of psychopathology <sup>52</sup> Social communication problems <sup>53</sup> Parental employment (self-coded method) <sup>54</sup> Socio-economic status**	

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6-8 years	Home	Parent	617 (60%)	<p>Child's eating behaviour **</p> <p>Child's risk factors for eating disorders <sup>55</sup></p> <p>Child's food environment <sup>56</sup></p> <p>Child physical activity environment **</p> <p>Parental concern about child's obesity in adulthood <sup>57</sup></p> <p>Parental perception of child's body shape <sup>58,59</sup></p> <p>Parental perception of child's activity <sup>60,8</sup></p> <p>Parent's attitudes and knowledge about food <sup>61-63</sup></p> <p>Maternal eating behaviour <sup>44</sup></p> <p>Parent's physical activity <sup>64</sup></p> <p>Parent food frequency <sup>65</sup></p> <p>Family health status **</p> <p>Parental employment (self-coded method) <sup>64</sup></p> <p>Socio-economic status</p> <p>Parents' body measurements; height, weight, waist, hip, bioelectrical impedance</p>	<p><b>Deleted:</b> General questions**¶</p> <p><b>Deleted:</b> Parental employment (self-coded method)<sup>64</sup>¶</p> <p>Socio-economic status**¶</p> <p>Child's physical activity by parent-recall diary <sup>53</sup>¶</p> <p>Parent food frequency <sup>54</sup>¶</p> <p><b>Deleted:</b> Parent's physical activity<sup>8</sup>¶</p>
			488 (47%)	DNA biomarkers (saliva sample)	
6-8 years	School	Teacher	576 (56%)	Common symptoms of psychopathology <sup>52</sup>	<b>Deleted:</b> Parent's physical activity <sup>8</sup> ¶
6-8 years	School	Child	619 (60%)	<p>Attitudes and knowledge about food <sup>62</sup></p> <p>Restrained eating <sup>66</sup></p> <p>Body image <sup>59</sup></p> <p>Habitual physical activity (accelerometry)<sup>67</sup></p> <p>Habitual sedentary behaviour (accelerometry)<sup>67</sup></p> <p>Body measurements; height, weight, waist, skinfolds (biceps, triceps, subscapular and supra-iliac), bone frame (knee, wrist, shoulders, hips and elbow) and bioelectrical impedance</p> <p>DNA biomarkers (saliva sample)</p>	<b>Deleted:</b> bony
			543 (53%)		
6-8 years	Home and school	Parents and observers	486 (47%)	Child's food intake over 4 days <sup>68</sup>	
6-8 years	Community premises	Parents and interviewers	37	Parent focus groups on childhood obesity	
		(Qualitative study)	16	Parent one-to-one interviews on childhood obesity	
8-10 years	Home	Parent	495 (48%)	Child's sedentary opportunities in the home <sup>69</sup>	<b>Deleted:</b> In progress
8-10 years	School	Child	590 (57%)	<p>Habitual physical activity (accelerometry)<sup>67</sup></p> <p>Habitual sedentary behaviour (accelerometry)<sup>67</sup></p> <p>Sports activity and how they feel physically <sup>70,71</sup></p> <p>Sedentary opportunities in the home<sup>69</sup></p> <p>Eating patterns <sup>72</sup> and appetite *</p> <p>Body image <sup>59</sup></p> <p>Body measurements; height, weight, waist, and bioelectrical impedance</p>	<p><b>Deleted:</b> ¶</p> <p>Child's physical activity by parent-recall diary <sup>53</sup></p> <p><b>Deleted:</b> In progress</p>

\* Influenced by previous work <sup>73</sup> or developed for the GMS

\*\* Items developed for the GMS

\*\*\* Non-validated, based on previous work

† Items relevant to six week infants used

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**Table 2. Socio-economic characteristics of mothers (based on data collected at birth)**

	Baseline		12 months		13 month health check		30 months		5-6 years		6-8 years		8-10 years	
	N=1011		N=624		N=830		N=482		N=495		N=605		N=576	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
<b>Townsend quintile*</b>														
1 (most affluent)	156	15	129	21	137	17	110	23	102	21	109	18	103	18
2	204	20	146	23	178	21	111	23	113	23	129	21	124	22
3	227	23	140	22	189	23	107	22	115	23	135	22	128	22
4	226	22	121	19	177	21	88	18	85	17	118	20	114	20
5 (least affluent)	192	19	83	13	143	17	61	13	75	15	108	18	101	18
Missing	6	1	5	1	6	1	5	1	5	1	6	1	6	1
<b>Qualification</b>														
A levels or above	243	24	186	30	213	26	150	31	159	32	175	29	167	29
GCSEs or equivalent	495	49	325	52	415	50	255	53	246	50	295	49	273	47
NVQ's or none	194	19	83	13	144	17	55	11	61	12	98	16	99	17
Missing	79	8	30	5	58	7	22	5	29	6	37	6	37	6

Percentages do not add up to 100 in all cases due to rounding

\* Based on Townsend deprivation index from 1991 census, using enumeration districts as the unit of analysis with the Northern Region of England as the population for comparison for the calculation of the quintiles

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	Baseline								6-8 years			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
<b>Townsend quintile*</b>												
1 (most affluent)	156	1.5	129	21	137	17	110	23	109	18	86	26
2	204	2.0	146	23	178	21	111	23	129	21	79	24
3	227	2.3	140	22	189	23	107	22	135	22	75	22
4	226	2.2	121	19	177	21	88	18	118	20	53	16
5 (least affluent)	192	1.9	83	13	143	17	61	13	108	18	37	11
Missing	6	.1	5	1	6	1	5	1	6	1	5	2
<b>Education</b>												
Degree or equivalent	166	1.6										
A levels or equivalent	77	.8										
GCSE or equivalent	495	4.9										
NVQs or none	194	1.9										
Missing	79	.8										
<b>Townsend quintile*</b>												
1 (most affluent)	15	15.8					111	17.9				
2	20	20.7					132	21.3				
3	23	23.3					140	22.6				
4	22	22.9					121	19.5				
5 (least affluent)	19	19.6					109	17.6				
Missing	6	6.0					6	1.0				
Totals	10	10.29					61	100.9				
		0						0				