

**sacn**

Scientific Advisory Committee on Nutrition

# Application of WHO Growth Standards in the UK

---

2007





# Application of WHO Growth Standards in the UK

Report prepared by the Joint SACN/RCPCH  
Expert Group on Growth Standards.

---

August 2007



Published by TSO (The Stationery Office) and available from:

**Online**

**[www.tsoshop.co.uk](http://www.tsoshop.co.uk)**

**Mail, Telephone, Fax & E-mail**

TSO

PO Box 29, Norwich, NR3 1GN

Telephone orders/General enquiries: 0870 600 5522

Fax orders: 0870 600 5533

E-mail: [customer.services@tso.co.uk](mailto:customer.services@tso.co.uk)

Textphone 0870 240 3701

**TSO Shops**

16 Arthur Street, Belfast BT1 4GD

028 9023 8451 Fax 028 9023 5401

71 Lothian Road, Edinburgh EH3 9AZ

0870 606 5566 Fax 0870 606 5588

**TSO@Blackwell and other Accredited Agents**

© Crown Copyright 2008. Published for the Food standards Agency and the Department of Health under licence from the Controller of Her Majesty's Stationery Office.

Applications for reproduction should be made in writing to the Office of Public Sector Information, Her Majesty's Stationery Office, 5th Floor, 102 Petty France, London, SW1H 9AJ.

ISBN 9780112432807

Printed in the united Kingdom by (TSO) The Stationery Office

N5909109 C20 10/09

**Acknowledgement**

Appendix 3: UK90 Growth charts © Child Growth Foundation, reproduced with permission

# Foreword

In 2006, following the publication of the WHO Child Growth Standards for children up to 5 years, the Department of Health asked the Scientific Advisory Committee on Nutrition (SACN), in collaboration with the Royal College of Paediatrics and Child Health (RCPCH), to advise on the applicability of the new standards for children aged 0-5 years in the UK.

This is the first time that SACN and RCPCH have worked so closely together and I would like to thank the Expert Group members for their participation in this successful collaboration on such a key issue. The recommendations of the Expert Group are important, as the adoption of the new standards would be a significant change to the existing UK Growth References and to how the growth of UK babies will be assessed.

The Expert Group undertook a scientific risk assessment and considered the suitability and applicability of the WHO Growth Standards to the growth of infants and children in the UK. The deliberations of the Expert Group are presented as a report in which the relative merits of adopting the WHO Growth Standards are highlighted.

In light of the Expert Group's recommendations (originally published online in August 2007), the Department of Health has since commissioned the RCPCH to undertake a project to pilot the use of the new integrated charts, and to develop training and information materials to support health professionals and parents to help with the interpretation and use of the new charts. RCPCH have set up a project team to develop a prototype chart for piloting and testing, and work is currently underway.

I would like to thank the Expert Group members and others for their contribution to this report. I commend the members of the Expert Group for undertaking this work within a short time scale and generously giving their time and expertise to carry out this work. I would also like to thank the Secretariat for their contribution to the production of this report.



Professor Alan Jackson  
Chair of the Scientific Advisory Committee on Nutrition (SACN) and Chair of  
the Joint SACN/RCPCH Expert Group

October 2008

# Contents

<b>1. Introduction</b>	<b>1</b>
Terms of Reference	2
<b>2. Background</b>	<b>3</b>
History of growth charts	3
<b>3. New WHO Growth Standards</b>	<b>5</b>
Growth reference versus standards	6
<b>4. Methodology</b>	<b>8</b>
<b>5. Comparison of WHO Growth Standards with UK1990 Growth References and UK Cohorts</b>	<b>9</b>
Suitability up to 2 years of age	10
Assumptions made	10
Birth to 4 months	10
Four months to 24 months	11
Suitability for 2-5 years (60 months) of age	14
<b>6. Preferred age between 24 and 60 months for joining the WHO Growth Standard and the UK1990 reference</b>	<b>16</b>
<b>7. Recommendations</b>	<b>18</b>
<b>References</b>	<b>20</b>
<b>Appendix 1</b>	<b>23</b>
Membership of the Joint SACN/RCPCH subgroup	23
<b>Appendix 2</b>	<b>25</b>
WHO Standards for weight, length/height and BMI centiles (boys and girls)	25

<b>Appendix 3</b>	<b>28</b>
UK1990 reference charts for weight, height/length and BMI up to the age of 5 years	28
<b>Appendix 4</b>	<b>33</b>
Comparison between the British 1990 (UK1990) reference and WHO Growth Standards using data from two representative UK population based birth cohorts	33
<b>Appendix 5</b>	<b>46</b>
Comparison between UK1990 reference versus WHO Growth Standards	46
<b>Appendix 6</b>	<b>49</b>
Impact of disjunction at 24, 36 and 48 months for weight, height and BMI (boys and girls)	49



# 1. Introduction

1. The World Health Organisation (WHO) published new Child Growth Standards for infants and children up to the age of 5 years in April 2006. These describe the growth of children living in a well-supported health environment in six different countries: Brazil, Ghana, India, Norway, Oman and USA. Standards were developed from a study which had a longitudinal follow-up until 24 months of age and a cross-sectional survey involving aged 18-71 months. The longitudinal and cross-sectional samples comprised infants who were exclusively<sup>1</sup> or predominantly<sup>2</sup> breastfed for at least four months, or three months respectively, with introduction of complementary foods by six months. In consequence, it is argued that the data describe “how children *should* grow” and represent a standard, rather than a reference describing “how children *are* growing” (Appendix 2).
2. In the UK, the Royal College of Paediatrics and Child Health (RCPCH) has recommended the use of UK1990 growth reference charts (Wright *et al*, 2002) which include weight, height, BMI, head circumference and stages of puberty, from birth to 20 years. These charts fit the contemporary data better than available alternatives and have been adopted widely both for monitoring growth in the clinical setting and cross-sectional assessment of population samples. However, it is recognized that these references do not describe the growth of exclusively breastfed infants, particularly with respect to weight, since the sample also included mixed and formula-fed infants.
3. Following adoption of the WHO Global Strategy on infant feeding in 2002, UK currently recommends exclusive breastfeeding for six months. Although there has been an increase in the initiation of breastfeeding,

<sup>1</sup> *Exclusive breastfeeding* - the infant has received only breastmilk from its mother or a wet nurse, or expressed breastmilk, and no other liquids or solids with the exception of drops or syrups consisting of vitamins, mineral supplements, or medicines (de Onis *et al*, 2004)

<sup>2</sup> *Predominant breastfeeding* - the infant's predominant source of nourishment has been breastmilk. However, the infant may also have received water and water-based drinks (e.g. sweetened and flavoured water, teas, infusions); fruit juice; oral rehydration solution (ORS); drop and syrup forms of vitamins, minerals and medicines; and ritual fluids (in limited quantities). With the exception of fruit juice and sugar water, no food-based fluid is allowed under this definition (de Onis *et al*, 2004)



now at 76% in the UK (Bolling *et al*, 2007), surveys show that this is not sustained. The Infant Feeding Survey (IFS) 2005 showed that of those who breastfed initially, 33% were still breastfeeding at 6 months, although only 5% were exclusively breastfeeding at 5 months. Although the early weight gain of breastfed infants exceeds that described by the UK1990 charts, it is followed by a slowing at about 12-weeks which some have claimed may prove a disincentive for continuing breastfeeding.

4. The Department of Health asked the Scientific Advisory Committee on Nutrition (SACN) for an opinion on the relevance of WHO Growth Standards to growth monitoring and population surveillance in the United Kingdom. A joint expert subgroup, comprising representatives of SACN, members nominated by RCPCH, and other experts was set up to discuss the issue (Appendix 1). The group's remit was to undertake a scientific risk assessment and advise on the applicability of WHO Growth Standards to UK children. Other management issues relating to their introduction, design, training and use by health professionals will be considered by Health Departments.

*Terms of Reference:*

5. To consider the suitability of the WHO Multicentre Growth Standards for use in the United Kingdom, specifically:
  - to consider the proposal that the WHO growth data reference constitutes a "standard"
  - to consider the implications for cross-sectional monitoring of the UK population, in particular the effect of its adoption on the number of children up to 60 months of age identified as underweight, wasted, overweight or of short stature
  - to consider the implications for the longitudinal growth monitoring of individuals
  - to consider any implications for guidance on infant and young child feeding practices and to make recommendations

## 2. Background

### *History of growth charts*

6. Growth references have been widely adopted for monitoring growth in the United Kingdom. The Tanner and Whitehouse chart in UK use from the 1960s, incorporated longitudinal data reflecting true velocity of growth. It also depicted standards for stages of pubertal development and variability in onset and duration of puberty (Tanner *et al*, 1966).
7. This was followed internationally by the production of reference curves from the US National Center for Health Statistics (NCHS) (Hamill *et al*, 1977). The US charts were adopted in 1978 for international use by WHO since no geographically diverse growth charts existed. The charts were used for both comparisons across populations (Waterlow *et al*, 1977) and for monitoring the growth of individual children (WHO, 1978). They have not been used to any extent for clinical monitoring in the United Kingdom.
8. The above charts formed a reference widely used to assess the nutritional status of infants and children. However, it was later recognized that the growth of breastfed infants, when plotted on these charts, rose steadily within the first weeks and then fell by one centile space (0.67 SD), raising problems for interpretation and practice (Whitehead & Paul, 1984; Wright, 2005). Moreover, most children on whom the Tanner charts were based were born in the 1950s and were fed breast milk substitutes rather than being exclusively breastfed and weaned early, before 3-4 months. It was also recognized that secular trends to increasing height and gender discrepancies could result in substantial sex bias in the identification of poor growth in early childhood, altering validity of the charts and highlighting the need for modification (Wright *et al*, 1996).
9. In 1990 an updated UK chart (UK1990) was compiled and introduced. It was based on more recent, larger cross-sectional data normalized to 1990. These UK1990 charts, currently in use, depict measurements

of weight, height, BMI, head circumference and stages of puberty, between birth and 20 years (Appendix 3).

10. The UK1990 charts used existing UK data from 17 different British sources and were constructed using Cole's LMS method, which adjusted for differing degrees of skewness at different ages and allowed for a choice of centiles; and the conversion of measurements to standard deviation scores (Cole and Green, 1992; Cole *et al* 1998).
11. The section of the UK1990 chart covering the first year of life was based on three sets of data: Whittington birthweight data, British Standards Institute and the Cambridge Infant Growth Study (Freeman *et al*, 1995). The UK1990 charts at this stage combined cross-sectional and longitudinal data and included a mix of breastfed and non-breastfed infants. These new charts appeared to fit infant growth patterns much better than the previous Tanner-Whitehouse charts.
12. The difference in growth pattern between formula and breastfed infants is well known (Whitehead and Paul, 1984; Dewey *et al*, 1995). On average breastfed infants gain weight rapidly in the first 3-4 months with respect to current references such as UK1990. This is evident visually as upward crossing of centiles, followed by downward crossing in later infancy (Hediger *et al*, 2000; Cole *et al*, 2002). By 12 months of age, breastfed infants may be as much as half a centile channel width lighter as a group than formula-fed infants. Cole *et al* (2002) highlighted the importance of this finding and provided breastfeeding specific centiles for professionals and parents to monitor the weight of long-term breastfed infants, (Cole *et al*, 2002) but these were based on small numbers of infants.
13. In 2002, the Royal College of Paediatrics and Child Health (RCPCH) convened an expert group to provide guidance on the validity of available growth charts, including Tanner-Whitehouse, Gairdner-Pearson, Buckler-Tanner and the new UK1990 growth references. They concluded that the 'UK1990 reference is the only suitable reference that can be recommended' (Wright *et al*, 2002) and also

recommended further improvements and refinements in the area of chart design using the UK1990 reference, particularly for the assessment of preterm neonates.

14. Currently UK1990 reference is used in surveillance as well as in clinical practice. For surveillance, the annual Health Survey for England classifies children above 85<sup>th</sup> centile as overweight and above 95<sup>th</sup> centile as obese. In clinical practice, individual children above 91<sup>st</sup> centile and 98<sup>th</sup> centile are classified as overweight or obese respectively.

### 3. New WHO growth standards

15. The use of local or national population references by health workers internationally, has caused many problems. This has topical relevance to monitoring the changing prevalence of obesity both in developed and developing countries, since a higher proportion of children than expected statistically falls in the upper centiles (Wright, 2005). The NCHS/WHO references were also inconsistent with WHO recommendations that babies be exclusively breastfed for the first six months of life since the growth pattern described was unrepresentative of infants so fed (Whitehead and Paul, 1984; Dewey *et al*, 1995).
16. In the early 1990s, WHO established a Working Group on infant growth, which conducted an evaluation of the NCHS/WHO growth reference and planned for the development of new growth charts, based only on the growth of healthy children in as close as possible to *optimal* conditions (Wright, 2005). These would document how children *should* grow in all countries rather than describing how they *do* grow at a particular time and place (Garza and de Onis, 2004).
17. The WHO Multicentre Growth Reference Study (MGRS) was implemented between 1997 and 2003, to develop standards consistent with WHO feeding recommendations and more relevant to children around the world.

18. In order for the MGRS to describe the growth of healthy children, screening criteria were applied at enrolment to exclude children likely to experience constrained growth. The study samples lived in favourable socioeconomic conditions and consisted of subjects with no known health or environmental constraints to growth. All mothers followed MGRS infant feeding recommendations, and did not smoke during or after pregnancy. Multiple births, preterm infants and those with significant morbidity were excluded. Low birthweight was not itself an exclusion criterion though the overall prevalence was low (2.1% over all sites).
19. The MGRS collected growth data from approximately 8500 infants and young children from a sample of six countries: Brazil, Ghana, India, Norway, Oman and USA. The study combined a longitudinal component from birth to 24 months, with a cross-sectional component of children aged 18-71 months. The standards are therefore based on longitudinal data up to 24 months and then on cross-sectional data from 24 - 60 months (de Onis *et al*, 2004) (Appendix 2).
20. The resulting WHO Growth Standards, from the MGRS study, have been incorporated into age-based charts for height, weight, and body mass index (BMI) that are intended for use by parents, doctors, and public health officials to monitor the growth of children and assess whether a child is too short, underweight, or overweight, for age.

### ***Growth reference versus standards***

21. A growth reference simply describes the growth of a sample of individuals without making any association with health, whereas a standard describes the growth of a 'healthy' population and suggests an aspirational model or target. The UK1990 growth charts currently in use constitute a reference as they combine growth data from several sets of UK children normalized to 1990, describing growth patterns at that time. The new WHO charts characterize the growth of children in an environment likely to favour achievement of their full genetic growth potential and are standards rather than a reference.

22. The feeding practices followed by infants who comprised the WHO MGRS dataset more closely reflect those currently recommended in the United Kingdom. These establish exclusive breastfeeding with introduction of complementary foods at six months as the norm. The MGRS reported insignificant between country variation in infants' length/height rates so fed, suggesting that the WHO Growth Standard would be representative of the growth of UK infants fed in a manner consistent with current national guidance.
23. Data from a sample of Swedish infants in whom optimal feeding patterns were supported by socio-economic conditions and general support for breastfeeding, suggested that such a chart would reflect the growth pattern of both predominantly and exclusively breastfed infants (Aarts *et al*, 2003).
24. Prior to their release, the WHO Growth Standards were field-tested in four countries, including two affluent countries (Argentina and Italy) and two less-affluent countries (Maldives and Pakistan). The main objective was to compare children's length/height-for-age and weight-for-length/height based on the new standards with clinician assessments of the same children. The authors concluded that the overall concordance between clinical assessments and the WHO standards-based indicators, confirmed that the standards were clinically and technically sound (Onyango *et al*, 2007).
25. The MGRS provides a hitherto unsurpassed foundation for a growth standard being based on healthy children living under conditions that favoured the achievement of full genetic potential. The MGRS data are also attractive as a standard for universal applicability because they include children from a range of countries, ensuring a variety of ethnic backgrounds and cultural settings (de Onis *et al*, 2004).
26. The new standards could be an effective tool for detecting both undernutrition and obesity, allowing for early identification of excessive weight gain, and help to address the double burden of malnutrition and obesity.

27. One potential concern about the MGRS dataset relates to the wide international variation in birthweights. Mean birthweight and maternal height in Oman and India, were lowest but were much higher in Norway and USA (Table 1). This suggests that maternal restraint may have operated on fetal growth in some MGRS samples and may explain the obvious difference in birthweight at term between the WHO Growth Standard and UK1990 reference. It is also feasible that early “catch up” growth operated as a consequence of maternal restraint in a significant proportion of MGRS infants.

**Table 1** Baseline characteristics of children in the longitudinal sample by site (adapted from Table V and VI WHO MGRS Group, 2006).

	Brazil (n = 310)	Ghana (n = 329)	India (n = 301)	Norway (n = 300)	Oman (n = 295)	USA (n = 208)	All (n = 1743)
Male, sex, %	52.3	48.9	54.2	53.3	50.2	50.0	51.5
Low birthweight, % (<2500g)	1.9	1.5	4.7	0.7	2.7	0.5	2.1
Birthweight, kg	3.3 ± 0.4	3.3 ± 0.4	3.1 ± 0.4	3.6 ± 0.5	3.2 ± 0.4	3.6 ± 0.5	3.3 ± 0.5
Birth length, cm	49.6 ± 1.9	49.4 ± 1.9	49.0 ± 1.8	50.4 ± 1.9	49.2 ± 1.7	49.7 ± 2.0	49.6 ± 1.9
Head circumference, cm	34.6 ± 1.1	34.3 ± 1.2	33.8 ± 1.2	34.9 ± 1.2	33.4 ± 1.0	34.2 ± 1.3	34.2 ± 1.3
Mother's height (cm)	161.1 ± 6.0		161.9 ± 5.2	157.6 ± 5.4	168.7 ± 6.6	156.6 ± 5.5	164.5 ± 6.9

## 4. Methodology

28. Validity of the WHO Growth Standards for assessing the size of UK infants was quantified using available data from two representative UK population based birth cohorts: Gateshead Millenium Baby Study (GMS) and a sub-sample from the Avon Longitudinal Study of Parents and Children (ALSPAC) (Appendix 4).
29. The GMS is a prospective population based cohort study of feeding and growth where 923 Caucasian infants, of 1029 infants born in Gateshead between 1999-2000, were used for the analysis. In the first 12 months parents completed various questionnaires relating to feeding, behaviour, development and illnesses, and each child attended a health check at 13 months of age and a follow-up check at 4-5 years.

30. The ALSPAC Children in Focus cohort is a sub-sample chosen at random from the last 6 months of ALSPAC births (6 June - 11 December 1992). ALSPAC is a large-scale cohort study comprising children born in the county of Avon during early 1990s.
31. Centiles and standard deviation scores (z-scores) from WHO Growth Standards and UK1990 references for weight, length/height and BMI were compared (Appendix 5). Although there is debate about the use of BMI as a measure for assessing adiposity in individual children, it is widely as acknowledged to be a population measure reflecting obesity risk. Below the age of 2 years, weight and length are the preferred parameters for monitoring growth rather than BMI. Therefore, in assessing differences between WHO Growth Standards and UK data, the analysis focused on weight and length in children below the age of 2 and on BMI in children above 2 years.
32. The effect of merging WHO Growth Standards with UK1990 reference at different ages was assessed. Figures in Appendix 6 illustrate disjunctions in weight, height and BMI centiles that would occur when the charts are merged at 24, 36 and 48 months.

## 5. Comparison of WHO growth standards with UK1990 growth references and UK cohorts

33. The main differences between the charts were observed in the first 2 years and particularly the first 2 months. Therefore the comparison initially focussed on the differences up to 24 months and then from 24 to 60 months. At the age of 2 years there is a discrepancy between the WHO and UK1990 charts for weight. In girls in the lower weight range, this difference approximates one centile band (0.67 SD) (Appendix 5). This gradually closes to become insignificant by the age of 5 years.



## *Suitability up to 2 years of age*

### *Assumptions made*

34. The WHO Growth Standards up to 2 years of age, are based on infants exclusively or predominantly breastfed for at least four months in a healthy environment and it was recognized that the breastfed infant exhibits a desirable pattern of growth, which is associated with healthier outcomes (Singhal and Lucas, 2004). The reliance on WHO Growth Standards as a descriptor of healthy growth could help to state clearly the desirability of breastfeeding in the UK.
35. A growing body of evidence suggests that a higher plane of growth during infancy is associated with increase in the risk of obesity in childhood (Baird *et al*, 2005; Ong and Loos, 2006). In this context the lower weight gain during late infancy (6-12 months) depicted by WHO Growth Standards when compared to UK1990 is likely to be beneficial to health.

### *Birth to 4 months*

36. Size at birth varies with gestational age. In contrast to the UK1990 references, WHO Growth Standards do not include preterm infants who require separate consideration. There is potential to retain the current UK1990 references for assessment of preterm infants but the plotting of postnatal measurements on birthweight centiles can be misleading, because preterm infant growth is quantitatively and qualitatively different to fetal growth at the same gestation. Moreover the normal postnatal weight loss is not reflected in birthweight charts.
37. WHO Growth Standards relate exclusively to term infants and have a single origin at birth regardless of actual gestational age between 37 - 42 weeks. Interpretation of data on weight in the first two weeks after birth is problematic due to:
  - the differences in mean birthweight between WHO and the UK1990 data noted above (paragraph 27) and the apparent rapid adjustment that occurs in the first two weeks

- the lack of distinction between data on birthweight at 40-42 weeks of gestation and infant weights at 0-2 weeks postnatal age, particularly in the UK1990 reference.
38. Mean weight and length of the WHO MGRS infants at birth fell below the 50th centile of the UK1990 reference (see paragraph 27). Therefore, against the WHO Growth Standards, UK populations appear large at birth and show apparent 'catch-down' growth by around one centile band (0.67 SD) during the first 2 to 4 months. There is a risk that such an early growth pattern might discourage some families from continuing breastfeeding. Thus it is suggested that WHO Growth Standards be used only beyond that point.
39. It is therefore appropriate to consider the adoption of WHO Growth Standards from 2 weeks of postnatal age, both to exclude birthweight and to omit the 2-week hiatus immediately following birth, as recommended by Wright & Parkinson (2004). This would entail having two charts: a birthweight reference from 23 weeks to 40 weeks of gestation to relate birthweight to a reference based on UK1990 references; and a post-natal chart from postnatal age of 2 weeks to 24 months of age based on WHO Growth Standards. This chart would deliberately omit centiles between term and 2 weeks post-term, for the reasons given above. In order to maintain continuity and for ease of use it would be advisable to formulate a combined presentation of the two charts covering both preterm infants and term infants with an appropriate explanation of the rationale for adopting post-natal charts from 2 weeks of postnatal age.
40. Beyond birth, the analysis of ALSPAC and GMS cohorts illustrated that the choice of growth chart had no effect on the standard deviation score (SDS) for length and so a changeover from UK1990 to new WHO Growth Standards is unlikely to result in major practical difficulties with regards to measuring length.

#### *Four months to 24 months*

41. For ALSPAC data there was a clear difference in weight gain between breastfed and bottle-fed infants from 4 to 24 months.

From 4-months old, a breastfed child is far less likely to be classified as underweight (falling below 2<sup>nd</sup> centile) using the WHO Growth Standards as opposed to the UK1990 reference (Table 2). Also using WHO Growth Standards, the proportion of UK infants classed as obese is higher than the UK1990 reference for both ALSPAC and GMS data, particularly at birth and at 12 months (Table 3). UK infants are also much more likely to be classified as overweight by BMI using the WHO Growth Standards. However as BMI is a measure not generally used in the first two years of life, this observation could be of limited practical significance.

42. The impact of using WHO Growth Standards for longitudinal weight gain monitoring was assessed. As expected, using WHO Growth Standards would greatly reduce the numbers of children who fall down though two centile bands in weight between 0-12 months (Appendix 4) (this measure currently serves as a primary care threshold for further investigation or concern) (Wright, 2000).
43. There are no important differences in length between the WHO and UK1990 charts at any age.

**Table 2** Proportion of breastfed only (+ non-smoking; + no solids at 2mo) children from ALSPAC data falling below the 2<sup>nd</sup> centile weight and BMI under the UK1990 growth reference and WHO growth standards

	% Below 2 <sup>nd</sup> Centile (ALSPAC)			
	WEIGHT		BMI	
	UK	WHO	UK	WHO
Birth	1.3	1.0	2.0	2.6
12 days				
8 weeks				
4 months	4.1	2.7	6.1	2.7
8 months	3.6	0.8	4.6	0.5
12 months	3.9	0.3	2.3	0.3
18 months	4.8	1.1	3.8	0.0
25 months	2.8	1.0	1.9	0.3
4-5 years	1.7	0.6	0.9	0.3

**Table 3** Proportion of children from ALSPAC and GMS data falling below the 2<sup>nd</sup> centile and above the 98<sup>th</sup> centile for weight, length/height and BMI under the UK1990 growth reference and WHO growth standards

## WEIGHT

	% Below 2 <sup>nd</sup> Centile				% Above 98 <sup>th</sup> Percentile			
	ALSPAC		GMS		ALSPAC		GMS	
	UK	WHO	UK	WHO	UK	WHO	UK	WHO
Birth	3.3	2.2	5.7	2.8	2.6	4.3	2.5	3.6
12 days			7.6	3.7			0.6	1.6
8 weeks			2.9	3.6			2.7	1.0
4 months	2.4	2.0	2.4	2.2	1.2	0.5	3.8	1.9
8 months	2.6	0.7	2.4	1.0	3.7	5.0	4.8	5.5
12 months	2.4	0.3	2.7	0.4	4.0	7.2	3.6	6.1
18 months	2.9	0.6			2.9	4.4		
25 months	2.1	0.8			3.4	3.5		
4-5 years	1.5	0.4	1.1	0.3	3.8	3.3	6.8	5.8

## LENGTH/HEIGHT

	% Below 2 <sup>nd</sup> Centile				% Above 98 <sup>th</sup> Percentile			
	ALSPAC		GMS		ALSPAC		GMS	
	UK	WHO	UK	WHO	UK	WHO	UK	WHO
Birth	2.6	0.8			2.0	9.4		
4 months	1.4	1.3			1.8	1.8		
8 months	1.6	1.5			2.1	2.9		
12 months	1.4	1.4			2.8	2.9		
18 months	2.2	2.8			2.1	1.7		
25 months	2.0	2.5			1.1	0.9		
4-5 years	1.2	1.9	1.8	2.3	1.7	0.8	2.2	1.5

## BMI

	% Below 2 <sup>nd</sup> Centile				% Above 98 <sup>th</sup> Percentile			
	ALSPAC		GMS		ALSPAC		GMS	
	UK	WHO	UK	WHO	UK	WHO	UK	WHO
Birth	2.4	2.9			2.6	1.6		
4 months	4.0	1.9			1.7	1.5		
8 months	3.1	0.7			3.2	5.6		
12 months	1.5	0.1			2.7	8.7		
18 months	2.2	0.2			2.6	8.0		
25 months	1.4	0.2			4.3	7.5		
4-5 years	0.9	0.1	0.6	0.0	5.0	7.2	8.3	10.1

44. In the US, similar observations were reported in a comparison of the 2006 WHO Growth Standards and CDC 2000 growth references. In June 2006, the Department of Health and Human Services (CDC and NIH) and the American Academy of Pediatrics, convened an expert group to consider using the new WHO charts for growth monitoring in the US. For infants aged 0-2 years, a direct comparison of the charts indicated that 'fewer US infants would be below the 5<sup>th</sup> percentile for weight-for-age using the WHO Growth Standards and more US infants would be above the 95<sup>th</sup> percentile' (Greer, 2006). The author also highlighted the need for additional guidance to health professionals on interpreting the outer centiles, if WHO Growth Standards were adopted. We concur with this advice.
45. de Onis *et al* (2007) evaluated the growth performance of healthy breastfed infants according to both WHO and CDC charts. They found the CDC charts reflected a heavier, and somewhat shorter, sample than the WHO sample. Thus application of the WHO Growth Standards yielded lower prevalence of undernutrition (except during the first 6 months of life) and higher prevalence of overweight and obesity. The authors concluded that adoption of the WHO Growth Standards in the US would have important implications for the assessment of lactation performance and the adequacy of infant feeding. They concluded that adopting the standards would bring coherence between the tools for assessing growth and the national guidelines, which recommend breastfeeding as the optimal source of nutrition during infancy (de Onis *et al*, 2007).

### ***Suitability for 2-5 years (60 months) of age***

46. Between ages 2-5 years the UK1990 growth references and WHO Growth Standards show no important differences in height and differences in weight SDS were less than those observed before 2 years. The US comparison of WHO Growth Standards and CDC 2000 charts for ages 2 to 5 years also observed that differences were relatively minor when compared to those between infant charts (Greer, 2006).

47. BMI SDS from UK1990 references and WHO Growth Standards begin to converge after the age of 2 years but some differences in centile spacing for weight and BMI between the two sets of data is evident particularly below the 50<sup>th</sup> centile (Appendix 6). A switch from WHO Growth Standards at the age of 5 or between 2 and 5 years would naturally create a disjunction in the chart.
48. Based on the above comparisons, it is concluded that:
- Adopting WHO Growth Standards between the ages of 2 weeks and 24 months is acceptable. It could be advantageous as they are based on infants exclusively or predominantly breastfed for at least 4 months and thus indicate a pattern of growth associated with favourable health outcomes.
  - There is little difference in UK1990 and WHO charts in terms of length or height at any age after birth.
  - Relative weights begin to converge from the age of 24 months and there may be little added advantage in adopting WHO Growth Standards beyond the age of 24 months.
  - The UK1990 reference would need to be maintained for assessing the birthweight of preterm infants. In order to address the differences in term birthweight between WHO Growth Standards and UK1990 references and to relate birthweight to a reference based on UK1990 references, it is advisable to adopt WHO Growth Standards from 2-weeks of postnatal age.
  - UK1990 reference charts do not adequately reflect the growth of exclusively breastfed infants. The national application of the new WHO Growth Standards, which closely reflect recommendations to exclusively breastfeed for the first six months of life, would reduce the proportion of breastfed infants currently referred as underweight or exhibiting growth faltering after 3-months of age.

## 6. Preferred age between 24 and 60 months for joining the WHO growth standard and the UK1990 reference

49. The WHO charts provide data to 60 months of age. Thus it is necessary to join the WHO Growth Standard and UK1990 reference at some point in order to compile a single growth chart spanning the age range from birth to 18-years.
50. The age at which to place this transition from the WHO Growth Standards to the UK1990 reference was discussed. The four options considered were 24, 36, 48 or 60 months of age
51. The WHO chart is based on cross-sectional data between 24-60 months, while data up to 24 months were obtained from a longitudinal study.
52. Measurement of standing height replaced measurement of supine length at 24 years. This explains the existing disjunction for length and BMI on the WHO chart. It follows that a second chart disjunction would be created if the transition between WHO and UK1990 charts were placed at later ages (36, 48 or 60 months).
53. Placing the transition from WHO to UK1990 data at 24 months rather than later ages may result in fewer children aged 25-months being classified as obese (4.3% vs. 7.5%) and more classified as underweight (1.4% vs. 0.2%) on the basis of BMI. Table 4 shows the numbers of children in the ALSPAC cohort who would be classified as underweight (<2<sup>nd</sup> centile) or obese (>98<sup>th</sup> centile) using either the WHO or UK1990 reference. The data indicate a narrowing of the discrepancy between references by 4-5 years of age, but even at two years of age the difference in numbers below the 2<sup>nd</sup> centile is small.

**Table 4** Proportion of children falling below 2<sup>nd</sup> centile and above 98<sup>th</sup> centile from ALSPAC study

	% below 2 <sup>nd</sup> centile BMI		% above 98 <sup>th</sup> centile BMI	
	WHO	UK1990	WHO	UK1990
25 months	0.2	1.4	7.5	4.3
4-5 years	0.1	0.9	7.2	5.0

Children following a particular centile on the WHO chart could also appear to drop as much as one centile band in weight on the second birthday, particularly in those in the lower part of the weight distribution (Appendix 5 and 6).

54. Differences between WHO and UK1990 centiles for weight at 36, 48 and 60 months are less than at 24 months, as they begin to converge after 24 months. However, as mentioned in paragraph 52, two disjunctions would be created in the merged BMI and height charts if the WHO Growth Standards were adopted to 36, 48 or 60 months. There would be one at 24 months due to the switch from length to height and another at 36, 48 or 60 months due to the transition to UK1990 reference. The effect of placing a disjunction at 24, 36 or 48 months is illustrated in Appendix 6.
55. Although the WHO Growth Standards and UK1990 centiles for weight and BMI converge closely by the age of 5 years (60 months) and hence allow a smoother transition between references, a change of reference at this age could create practical difficulties. A disjunction after 48-months (for example at 60 months) has been discounted because National school entry surveillance has customarily adopted UK1990 charts at around 5 years of age. Placing the disjunction between the ages of 24 months and 48 months is likely to be more acceptable as there is no current routine national monitoring between these ages.
56. In summary, adopting the charts to 24 months would appear preferable on the following grounds:
- there is already a disjunction at this age when measurement changes from supine length to standing height. Two disjunctions would thus be avoided



- this is the point at which WHO data changes from longitudinal to cross-sectional.
- it would reduce the proportion of infants being classified as *growth faltering* or underweight, thus alleviating concerns regarding the lower weight gain observed in breastfed infants during later infancy.
- It would not create difficulties for National school entry surveillance programmes

## 7. Recommendations

57. Exclusive breastfeeding to the age of six months with continued breastfeeding as part of a progressively varied diet is recommended for all infants. WHO Growth Standards describe the growth of infants in good health who were exclusively or predominantly breastfed for at least 4 months. They are applicable to all infants, whether breast or formula-fed. The new standards may help to establish exclusive breastfeeding as the norm in the first half of infancy.
58. When compared to the UK1990 reference WHO Growth Standards depict a pattern of slower weight gain between 4 to 24 months and should be preferred to UK1990 references during this period. Current evidence suggests that such a pattern of growth could potentially reduce the risk of later obesity.
59. WHO Growth Standards represent a pattern of linear growth, which is remarkably consistent between different countries and ethnic groups following recommended feeding practices. They are applicable to all children in the UK, including those from ethnic minority groups.
60. The UK1990 Growth References should be used in line with current practice for monitoring the growth of preterm infants and children over the age of 24 months.

61. The Committee specifically recommend adopting the new WHO Growth Standards from 2 weeks to take account of the differences in birthweight, gestational age and the adjustment in weight that often occurs in the first two weeks after birth.
62. The optimum age at which the transition between WHO and UK1990 references might be made cannot be stated on scientific grounds. A disjunction must arise in every case at 2 years (because of the transition between supine length and height measurement and, to a lesser degree, transition from the WHO longitudinal to the cross-sectional data set). Transferring from WHO data to UK1990 data at any age later than 2-years would create two disjunctions, rather than one on the BMI chart and this may be undesirable. Transferring as late as 5-years could impact on school-entry national surveillance programmes.
63. The feasibility of using WHO Growth Standards from 2-weeks of postnatal age to 24 months and UK1990 from 24 months onwards requires piloting and field-testing before being formally adopted.
64. Health professionals involved in child health are likely to require additional training and guidance on the use and interpretation of WHO Growth Standards and UK1990 references for monitoring growth in clinical practice. Adequate training for health professionals should include clear guidance on the monitoring of infants in the first two weeks after birth.
65. Adoption and implementation of the charts should be preceded by a well-planned communications strategy and should include the use of standardized training and information materials to ensure that parents and carers receive clear and consistent advice.

## References

Aarts, C., Kylberg, E., Hofvander, Y. & Gebre-Medhin, M. (2003) Growth under privileged conditions of healthy Swedish infants exclusively breastfed from birth to 4-6 months: a longitudinal prospective study based on daily records of feeding. *Acta Paediatrica* 92, 145-151

Baird, J., Fisher, D., Lucas, P., Kleijnen, J., Roberts, H. & Law, C. (2005) Being big or growing fast: systematic review of size and growth in infancy and later obesity. *BMJ* 331(7522), 929

Bolling, K., Grant, C., Hamlyn, B. & Thornton, A. (2007) Infant Feeding Survey 2005. <http://www.ic.nhs.uk/statistics-and-data-collections/health-and-lifestyles/infant-feeding/infant-feeding-survey-2005> Accessed May 2007

Centers for Disease Control and Prevention. CDC Growth Charts: United States. Centers for Disease Control and Prevention [website]. Available at: [www.cdc.gov/growthcharts](http://www.cdc.gov/growthcharts). Accessed November 2006

Cole, T.J., Freeman, J.V. & Preece, M.A. (1998) British growth reference centiles for weight, height, body mass index and head circumference fitted by maximum penalized likelihood. *Statistics in Medicine* 17(4), 407-429

Cole, T.J. & Green, P.J. (1992) Smoothing reference centile curves: the LMS method and penalized likelihood. *Stat Med* 11, 1305-1319

Cole, T.J., Paul, A.A. & Whitehead, R.G. (2002) Weight reference charts for British long-term breast-fed infants. *Acta Paediatrica* 91, 1296-1300

de Onis, M., Garza, C., Victora, C.G., Bhan, M.K., Norum, K.R. & guest editors (2004) The WHO Multicentre Growth Reference Study (MGRS): Rationale, planning and implementation. *Food and Nutrition Bulletin* 25(1), Supplement 1

de Onis, M., Garza, C., Victora, C.G., Onyango, A.W., Frongillo, E.A. & Martines, J. (2004) The WHO Multicentre Growth Reference Study

(MGRS): Planning, study design, and methodology. *Food and Nutrition Bulletin* 25(1), Supplement 1

de Onis, M., Garza, C., Onyango, A.W. & Borghi, E. (2007) Comparison of the WHO Child Growth Standards and the CDC 2000 Growth Charts. *Journal of Nutrition* 137, 144-148

Dewey, K.G., Peerson, J.M., Brown, K.H., Krebs, N.F., Michaelson, K.F., Persson, L.A. *et al* (1995) Growth of breast-fed infants deviates from current reference data: A pooled analysis of US, Canadian and European datasets. *Pediatrics* 96, 495-503

Freeman, J.V., Cole, T.J., Chinn, S., Hones, P.R.M., White, E.M. & Preece, M.A. (1995) Cross-sectional stature and weight reference curves for the UK. *Arch Dis Child* 73, 17-24

Garza, C. & de Onis, M. (2004) Rationale for developing a new international growth standard. *Food and Nutrition Bulletin* 25(1), Supplement 1

Greer, A.A.P. (2006) Groups compare CDC, WHO growth curves. *American Academy of Pediatrics News* 27: 1-22 <http://aapnews.aapublications.org/cgi/content/full/27/9/1-b> Accessed December 2007

Hamill, P.V., Drizd, T.A., Johnson, C.L., Reed, R.B. & Roche, A.F. (1977) NCHS growth curves for children birth-18 years, United States. *Vital Health Stat* 11(165), 1-74

Hediger, M.L., Overpeck, M.D., Ruan, W.J. & Troendle, J.F. (2000) Early infant feeding and growth status of US-born infants and children aged 4-71 mo: analyses from the third National Health and Nutrition Examination Survey, 1988-1994. *Am J Clin Nutr* 72, 159-67

Ong, K.K. & Loos, R.J. (2006) Rapid infancy weight gain and subsequent obesity: systematic reviews and hopeful suggestions. *Acta Paediatr* 95(8), 904-8

Onyango, A.W., de Onis, M., Caroli, M., Shah, U., Sguassero, Y., Redondo, N. & Caroli, B. (2007) Field-Testing the WHO Child Growth Standards in Four Countries. *Journal of Nutrition* 137, 149-152

Singhal, A. & Lucas, A. (2004) Early origins of cardiovascular disease: is there a unifying hypothesis? *The Lancet* 363, 1642-1645

Tanner, J., Whitehouse, R. & Takaishi, M. (1966) Standards from birth to maturity for height weight height velocity and weight velocity: British children 1965 Part I. *Arch Dis Child* 41, 454-71

Waterlow, J.C., Buzina, R., Keller, W., Lane, J.M., Nichaman, M.Z. & Tanner, J.M. (1977) The presentation and use of height and weight data for comparing the nutritional status of groups of children under the age of 10 years. *Bull. WHO* 55:489-498

Whitehead, R.G. & Paul, A.A. (1984) Growth charts and the assessment of infant feeding practices in the Western world and in developing countries. *Early Hum. Dev.* 9, 187-207

WHO Multicentre Growth Reference Study Group (2006) Enrolment and baseline characteristics in the WHO Multicentre Growth Reference Study. *Acta Paediatrica* Suppl 450, 7-15

World Health Organization (1978) A growth chart for international use in maternal and child health care. Guidelines for primary health care personnel. Geneva: World Health Organization.

Wright, C.M. (2000) The identification and management of failure to thrive: a community perspective. *Arch Dis Child* 82, 5-9

Wright, C.M. (2005) Growth charts for babies. *British Medical Journal* 330, 1399-1400

Wright, C.M., Booth, I.W., Buckler, J.M.H., Cameron, N., Cole, T.J., Healy, M.J.R., Hulse, J.A., Preece, M.A., Reilly, J.J. & Williams, A.F. (2002) Growth reference charts for use in the United Kingdom. *Arch Dis Child* 86, 11-14

Wright, C., Corbett, S., & Drewett, R. (1996) Sex differences in weight in infancy and the British 1990 growth standards. *BMJ* 313, 513-4

Wright, C.M. & Parkinson, K.N. (2004) Postnatal weight loss in term infants: what is normal and do growth charts allow for it? *Arch Dis Child Fetal Neonatal Ed* 89, F254

# Appendix 1

## Membership of the Joint SACN/RCPCH subgroup:

### Chairman

Professor Alan Jackson      Professor of Human Nutrition, Southampton General Hospital

### Members

Dr Anthony Williams      Reader in Child Nutrition and Consultant in Neonatal Paediatrics, St George's University of London

Professor Peter Aggett      Head of School, Lancashire School of Health and Medicine, Professor of Child and Health Nutrition, University of Central Lancashire

Mrs Stella Walsh      Senior Lecturer, Leeds Metropolitan University

Professor Tim Cole      Professor of Medical Statistics, Institute of Child Health, London

Dr David Elliman      Consultant in Community Child Health, Islington PCT and Great Ormond Street Hospital.

Dr Ken Ong      MRC Group Leader & Hon. Consultant Paediatric Endocrinologist, MRC Epidemiology Unit, Cambridge

Dr Charlotte Wright      Professor of Community Child Health / Consultant Paediatrician, Glasgow University, Yorkhill Children's Hospital

Dr Barbara Golden      Clinical Senior Lecturer, Child Health & Honorary Consultant, International Child Health

**Secretariat**

*Scientific*

Dr Sheela Reddy

Department of Health

Rachel Coomber

Department of Health

*Administrative*

Johnson Phillip

Department of Health

Parminder Nijjar

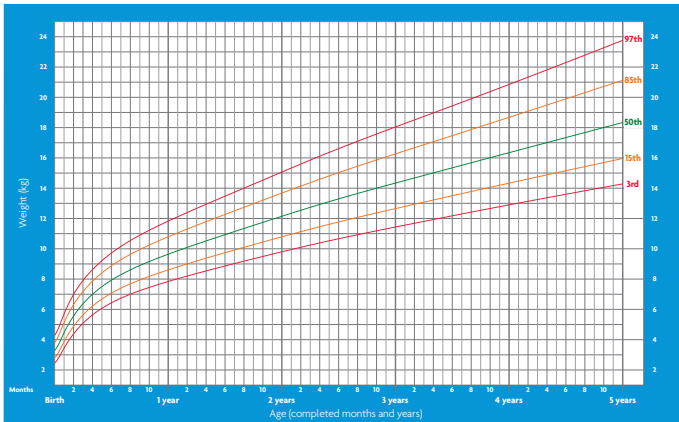
Department of Health

# Appendix 2

WHO Growth Standards for weight, length/height and BMI centiles (boys and girls)  
(<http://www.who.int/childgrowth/standards/en/>)

## Weight-for-age BOYS

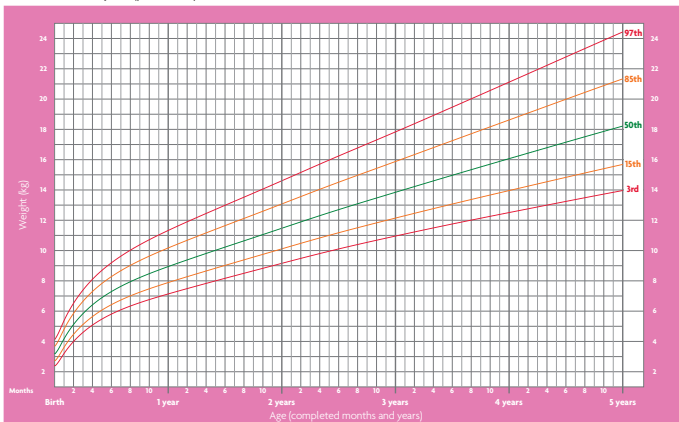
Birth to 5 years (percentiles)



WHO Child Growth Standards

## Weight-for-age GIRLS

Birth to 5 years (percentiles)

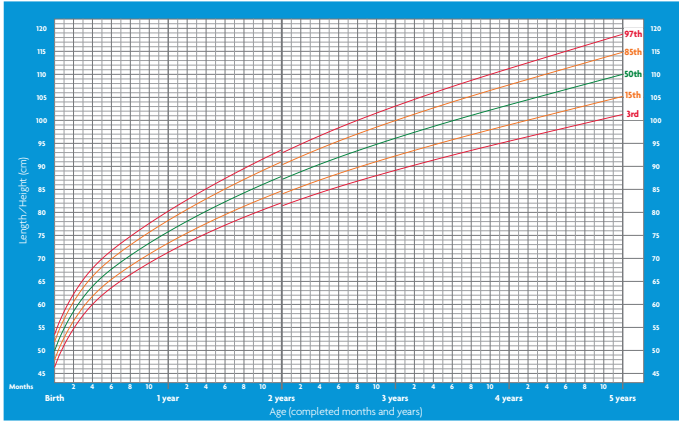


WHO Child Growth Standards



### Length/height-for-age BOYS

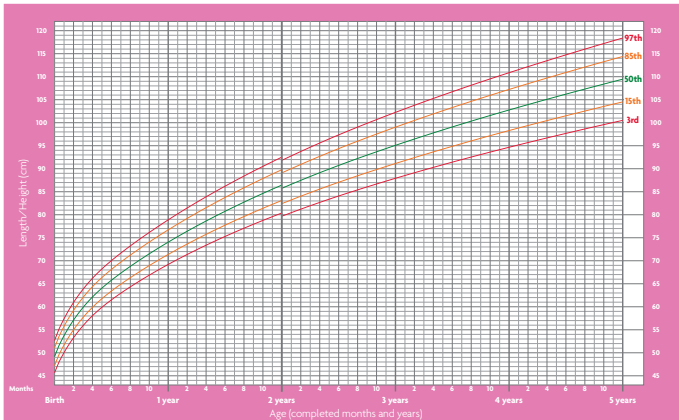
Birth to 5 years (percentiles)



WHO Child Growth Standards

### Length/height-for-age GIRLS

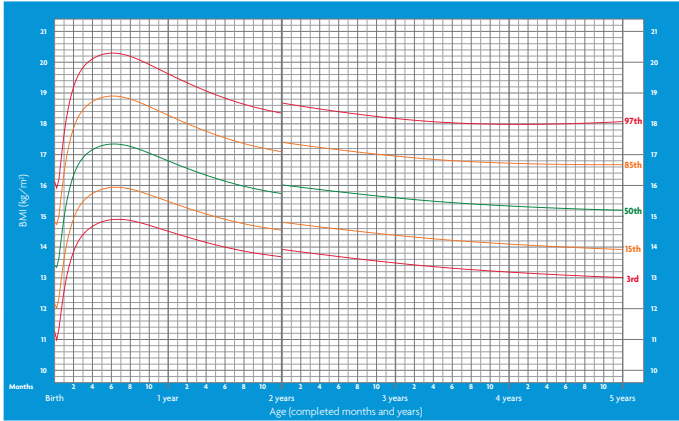
Birth to 5 years (percentiles)



WHO Child Growth Standards

### BMI-for-age BOYS

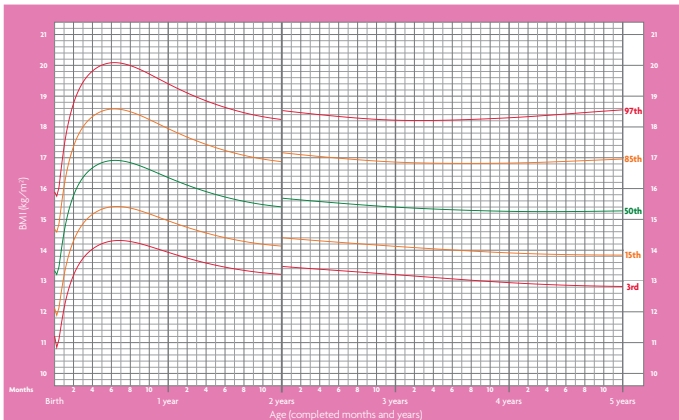
Birth to 5 years (percentiles)



WHO Child Growth Standards

### BMI-for-age GIRLS

Birth to 5 years (percentiles)

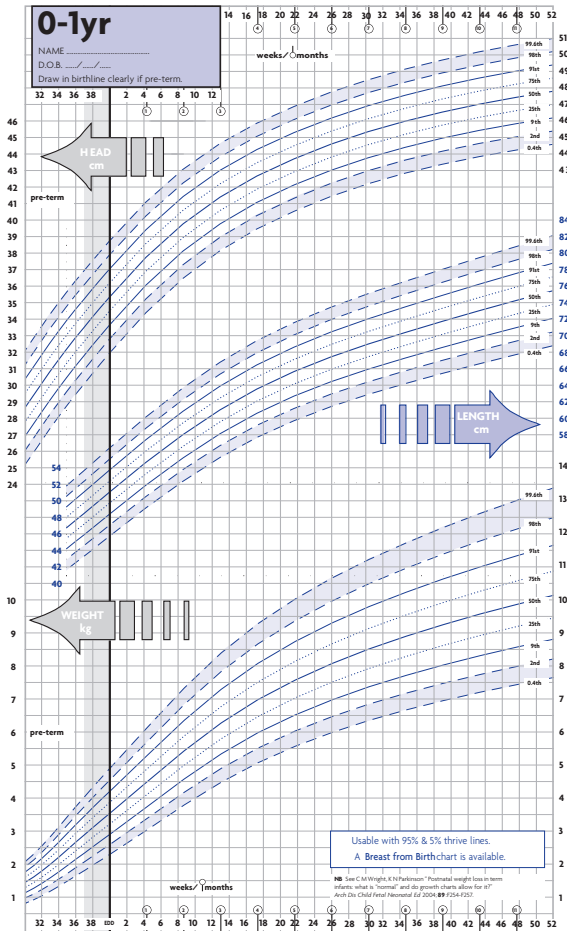


WHO Child Growth Standards

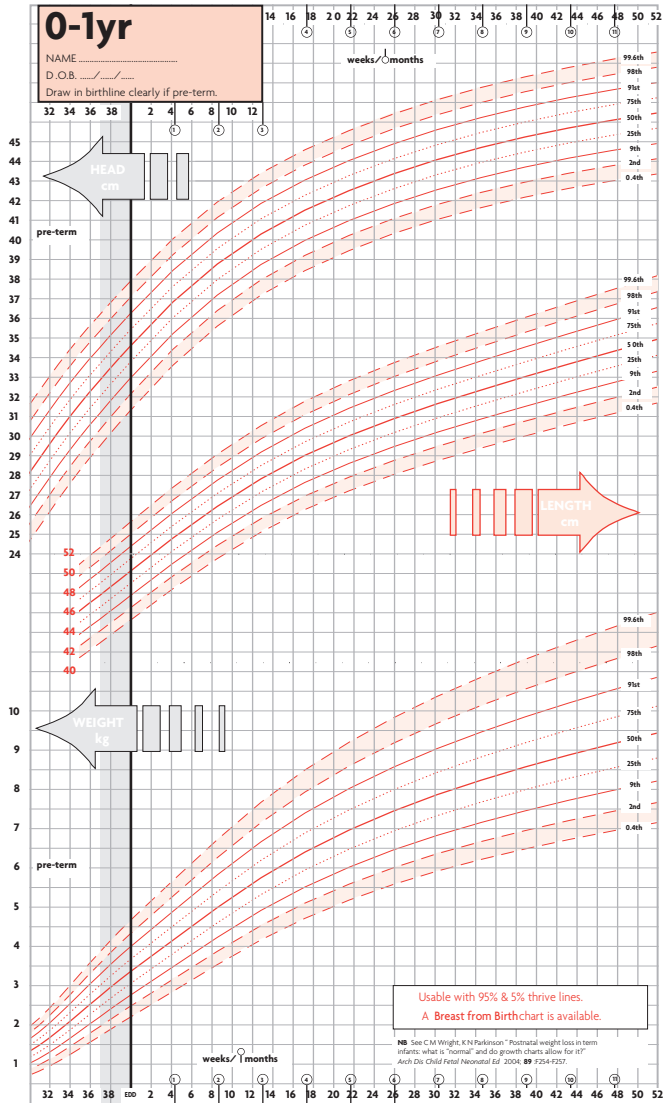
# Appendix 3

## UK1990 reference charts for weight, height/length and BMI up to the age of 5 years

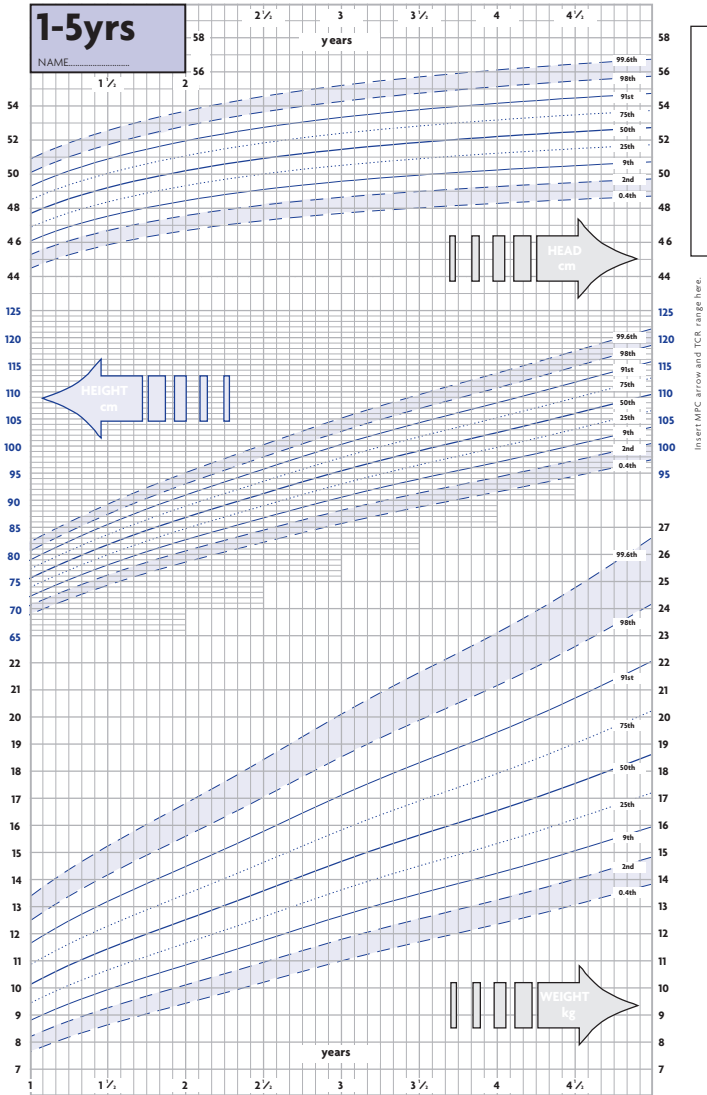
### Boys 0-1 yrs (Weight and Length/Height)



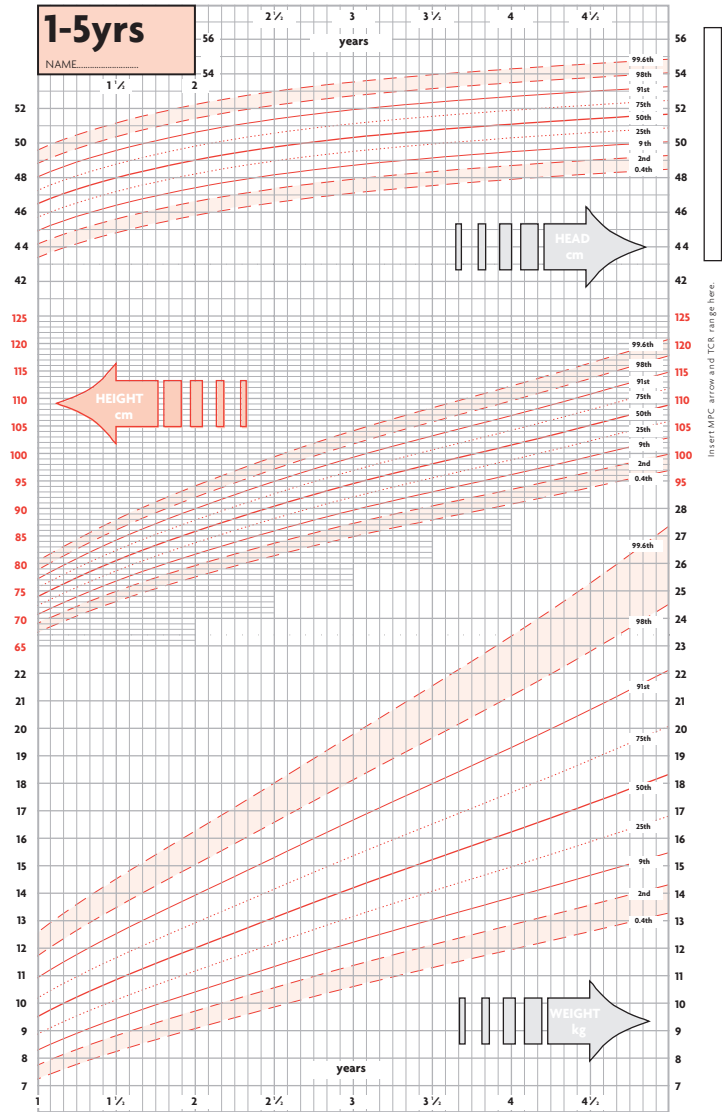
### Girls 0-1 yrs (Weight and Length/Height)



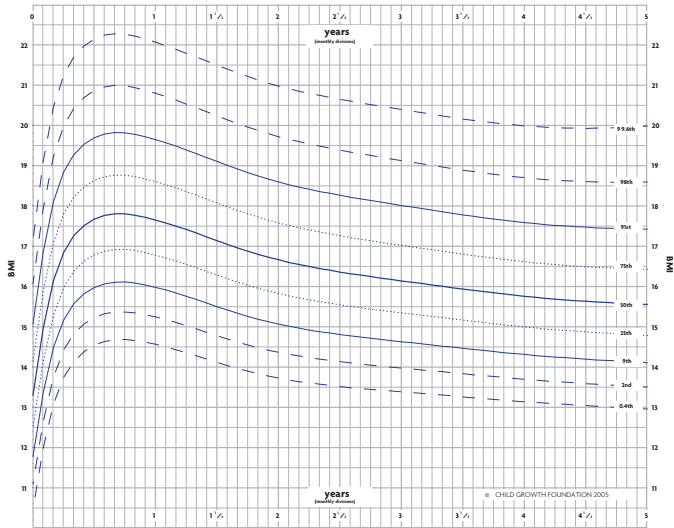
### Boys 1-5 yrs (Weight and Length/Height)



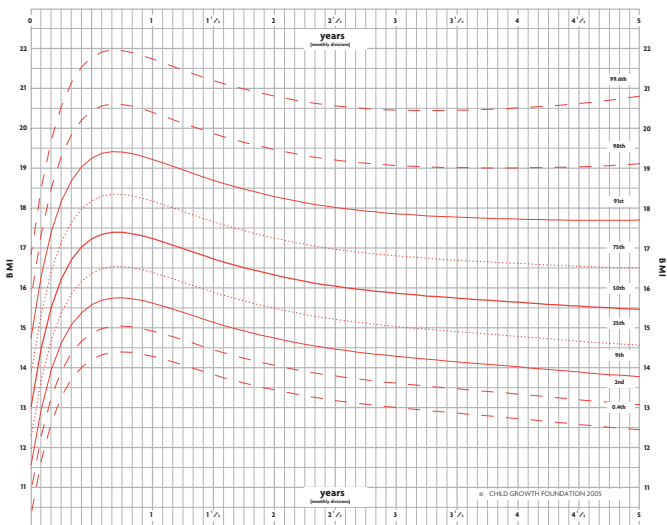
### Girls 1-5 yrs (Weight and Length/Height)



### Boys 0-5 yrs (BMI)



### Girls 0-5 yrs (BMI)



## Appendix 4

### Comparison between the British 1990 (UK1990) reference and WHO 2006 Growth Standards using data from two representative UK population based birth cohorts

#### Introduction

This report was prepared in order to assess the impact of changing from the British 1990 to the WHO 2006 Growth Standards using available data from two 'representative' UK population-based studies.

The WHO 2006 cohort were lighter at birth (mean birth weight 3.3 kg), but fairly similar to the UK1990 by 2 months, and then lighter again after 6 months.

#### Description of the two UK population-based studies, including numbers at each visit and the definition of breast-feeding used.

##### Gateshead Millennium Baby Study (GMS)

Prospective population based cohort study of feeding and growth 1029 infants born between 1999-2000; 923 term Caucasian infants used for this analysis Breast feeding: 50% @birth, 10% @4m

Routine weights and feeding information sent in by parents throughout first year

School entry measurements retrieved aged 4-5

Measurements available:

	Weight	Height
Birth	923	
12 days	806	
8 wks	788	
4m	796	
8m	601	
12m	764	
School entry (4-5)	399*	399*

\*Only available for those measured <5yrs



Avon Longitudinal Study of Parents and Children (ALSPAC): “Children in Focus”

1335 infants born in Avon district 1991-2

Breastfeeding: 46% @3m (includes up to 1 formula feed per day)

Measured at research study clinics

Measurements available:

	<b>Weight</b>	<b>Height</b>
Birth	1334	1115
4m	943	944
8m	1231	1230
12m	1164	1163
18	1088	1090
24	1049	977
5 years	929	927

**Tables of Means, % above 98<sup>th</sup> centile and % below 2<sup>nd</sup> centile:  
for weight, length/height, and BMI according to UK1990 growth  
reference and WHO 2006 Growth Standards.**

**ALL CHILDREN (Breast + Formula groups)**

**WEIGHT**

**1. Mean SD scores**

	ALSPAC		GMS	
	UK	WHO	UK	WHO
Birth	0.0	0.3	-0.2	0.2
12 days			-0.5	-0.1
8 weeks			0.0	-0.2
4 months	-0.1	-0.1	0.0	0.0
8 months	0.1	0.5	0.2	0.5
12 months	0.2	0.6	0.1	0.5
18 months	0.1	0.5		
25 months	0.1	0.4		
4-5 years	0.3	0.4	0.5	0.5

**2. Percentage below 2<sup>nd</sup> centile**

	ALSPAC		GMS	
	UK	WHO	UK	WHO
Birth	3.3	2.2	5.7	2.8
12 days			7.6	3.7
8 weeks			2.9	3.6
4 months	2.4	2.0	2.4	2.2
8 months	2.6	0.7	2.4	1.0
12 months	2.4	0.3	2.7	0.4
18 months	2.9	0.6		
25 months	2.1	0.8		
4-5 years	1.5	0.4	1.1	0.3

**3. Percentage above 98<sup>th</sup> centile**

	ALSPAC		GMS	
	UK	WHO	UK	WHO
Birth	2.6	4.3	2.5	3.6
12 days			0.6	1.6
8 weeks			2.7	1.0
4 months	1.2	0.5	3.8	1.9
8 months	3.7	5.0	4.8	5.5
12 months	4.0	7.2	3.6	6.1
18 months	2.9	4.4		
25 months	3.4	3.5		
4-5 years	3.8	3.3	6.8	5.8

**LENGTH / HEIGHT****4. Mean SD scores**

	<b>ALSPAC</b>		<b>GMS</b>	
	<b>UK</b>	<b>WHO</b>	<b>UK</b>	<b>WHO</b>
Birth	0.0	0.6		
4 months	-0.1	0.0		
8 months	0.1	0.2		
12 months	0.1	0.1		
18 months	0.0	-0.1		
25 months	-0.1	-0.1		
4-5 years	0.1	-0.1	0.0	-0.2

**5. Percentage below 2<sup>nd</sup> centile**

	<b>ALSPAC</b>		<b>GMS</b>	
	<b>UK</b>	<b>WHO</b>	<b>UK</b>	<b>WHO</b>
Birth	2.6	0.8		
4 months	1.4	1.3		
8 months	1.6	1.5		
12 months	1.4	1.4		
18 months	2.2	2.8		
25 months	2.0	2.5		
4-5 years	1.9	1.9	1.8	2.3

**6. Percentage above 98<sup>th</sup> centile**

	<b>ALSPAC</b>		<b>GMS</b>	
	<b>UK</b>	<b>WHO</b>	<b>UK</b>	<b>WHO</b>
Birth	2.0	9.4		
4 months	1.8	1.8		
8 months	2.1	2.9		
12 months	2.8	2.9		
18 months	2.1	1.7		
25 months	1.1	0.9		
4-5 years	1.7	0.8	2.2	1.5

**BMI****7. Mean SD scores**

	ALSPAC		GMS	
	UK	WHO	UK	WHO
Birth	0.2	0.0		
4 months	-0.1	-0.1		
8 months	0.1	0.5		
12 months	0.2	0.8		
18 months	0.1	0.8		
25 months	0.3	0.7		
4-5 years	0.4	0.6	0.7	0.9

**8. Percentage below 2<sup>nd</sup> centile**

	ALSPAC		GMS	
	UK	WHO	UK	WHO
Birth	2.4	2.9		
4 months	4.0	1.9		
8 months	3.1	0.7		
12 months	1.5	0.1		
18 months	2.2	0.2		
25 months	1.4	0.2		
4-5 years	0.9	0.1	0.6	0.0

**9. Percentage above 98<sup>th</sup> centile**

	ALSPAC		GMS	
	UK	WHO	UK	WHO
Birth	2.6	1.6		
4 months	1.7	1.5		
8 months	3.2	5.6		
12 months	2.7	8.7		
18 months	2.6	8.0		
25 months	4.3	7.5		
4-5 years	5.0	7.2	8.3	10.1

**Tables of Means, % below 2<sup>nd</sup> centile: for weight, length/height, and BMI according to UK1990 growth reference and WHO 2006 Growth Standards but restricted to a breastfed sub-group that is more representative of the WHO populations.**

**BREAST-FED (+ non-smoking; +no solids at 2mo)**

**WEIGHT**

**10. Mean SD scores**

	ALSPAC		GMS	
	UK	WHO	UK	WHO
Birth	0.1	0.5	0.0	0.3
12 days			-0.4	0.0
8 weeks			0.0	-0.1
4 months	-0.3	-0.2	-0.1	-0.1
8 months	-0.1	0.2	0.0	0.3
12 months	0.0	0.5	0.0	0.5
18 months	-0.1	0.4		
25 months	0.0	0.3		
4-5 years	0.3	0.3	0.4	0.2

**11. Percentage below 2nd centile**

	ALSPAC		GMS	
	UK	WHO	UK	WHO
Birth	1.3	1.0		
12 days				
8 weeks				
4 months	4.1	2.7		
8 months	3.6	0.8		
12 months	3.9	0.3		
18 months	4.8	1.1		
25 months	2.8	1.0		
4-5 years	1.7	0.6		

**BMI****12. Mean SD scores**

	ALSPAC		GMS	
	UK	WHO	UK	WHO
Birth	0.2	0.0		
4 months	-0.3	-0.3		
8 months	-0.1	0.3		
12 months	0.1	0.7		
18 months	0.0	0.7		
25 months	0.2	0.6		
4-5 years	0.4	0.6	0.4	0.4

**13. Percentage below 2nd centile**

	ALSPAC		GMS	
	UK	WHO	UK	WHO
Birth	2.0	2.6		
12 days				
8 weeks				
4 months	6.1	2.7		
8 months	4.6	0.5		
12 months	2.3	0.3		
18 months	3.8	0.0		
25 months	1.9	0.3		
4-5 years	0.9	0.3		

**Comments:**

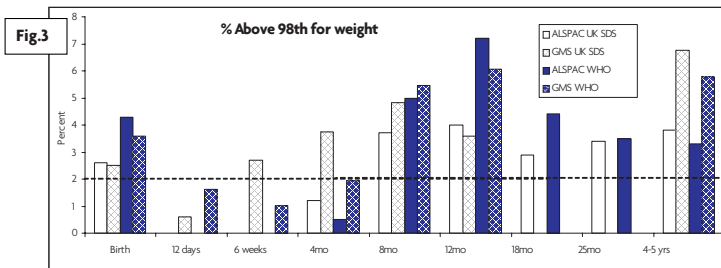
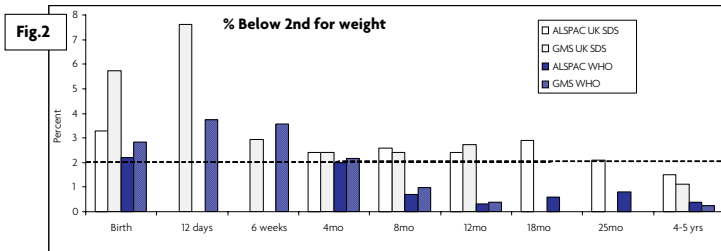
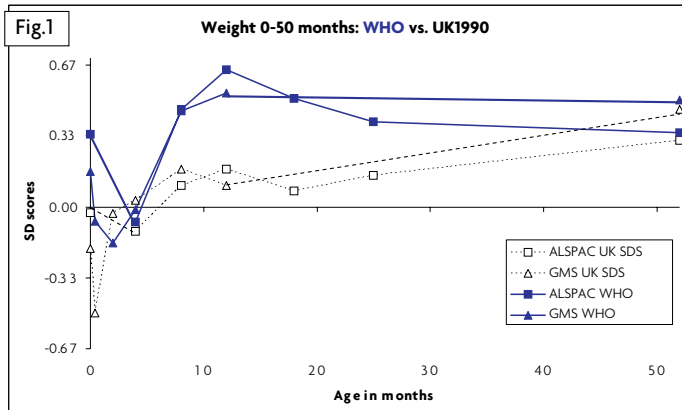
- The percentages highlighted in Light-blue illustrate the potential over-labelling of normal breast-fed infants as underweight using the UK 1990 reference. It is much harder to be underweight using WHO 2006.
- There would be an increase in overweight on changing from the British 1990 to the WHO 2006 charts, however the effect is less at 4-5 years than at earlier ages.

The following figures present the above table data in graphical format. Figures 1 & 4 best illustrate the differences in mean weight SD score (SDS) during infancy (in all children or breastfed alone) based on British 1990 (thin black lines) or WHO 2006 (bold blue lines) data.

Comments:

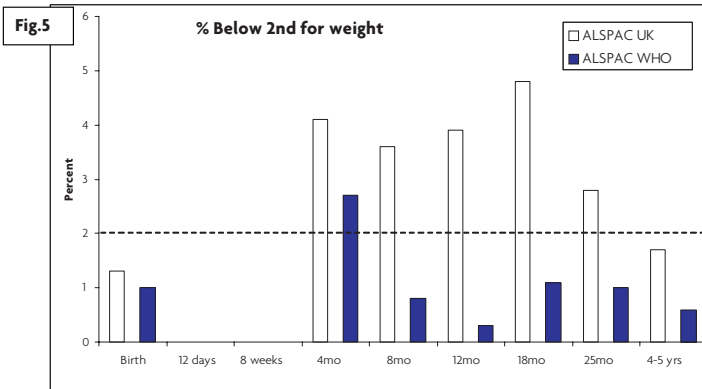
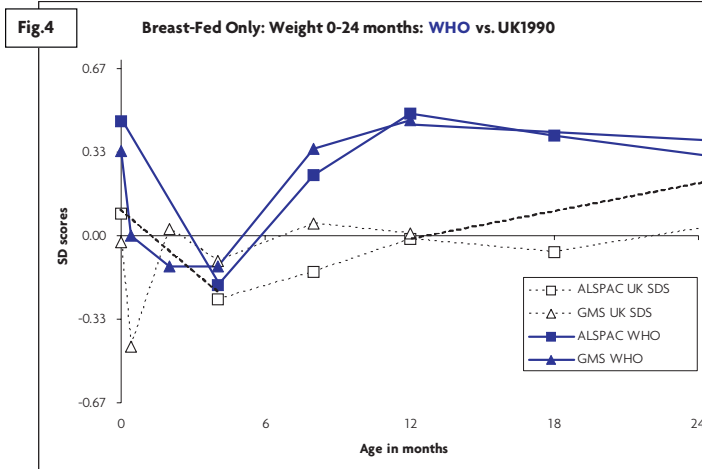
- *Birth to 4 months: Using WHO 2006, both UK populations have relatively high birth weight SDS, and rapidly show relative 'catch-down' in weight SDS during the first couple of months. Note: a very similar pattern is seen if the UK1990 median is plotted on WHO 2006, with weight at birth = +0.4 SDS; and weight at 2 months = -0.2 SDS (not shown).*
- *Length SDS shows a similar early pattern using WHO 2006 (Figure 6)*
- *4 months to 5 years: The expected larger weight SDS using WHO 2006 is most apparent during the first 2 years, but by 5 years there is little difference.*
- *Length SDS is unaffected by choice of chart beyond birth.*

## Weight: All Children

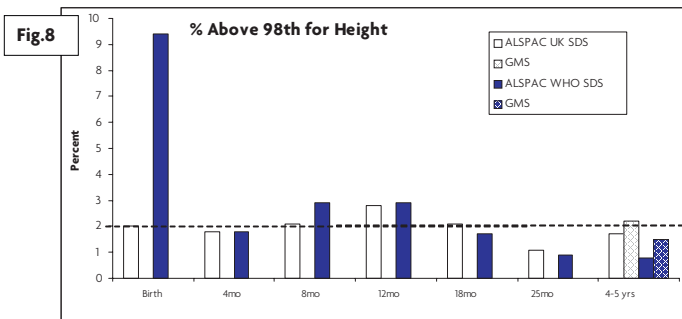
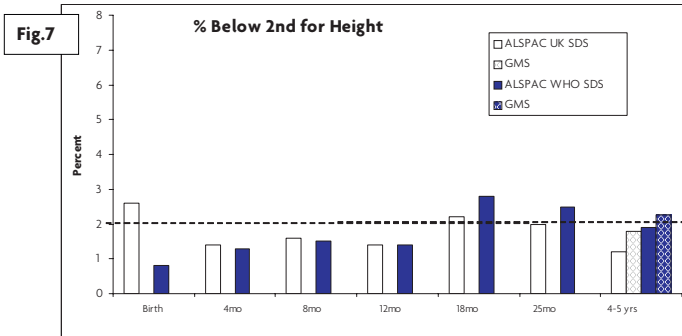
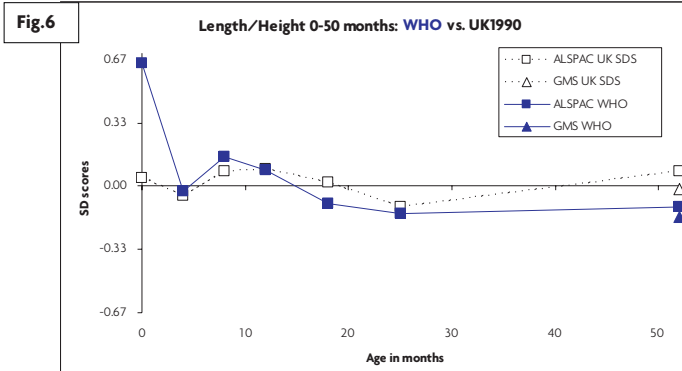




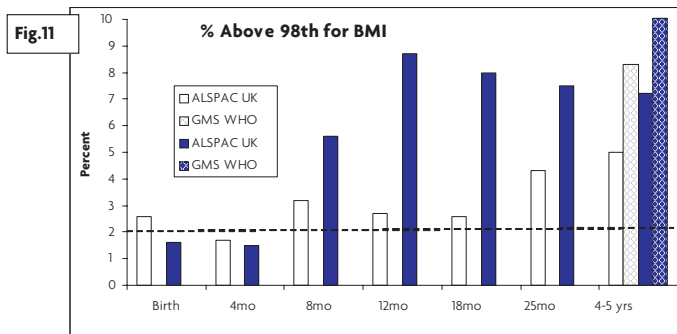
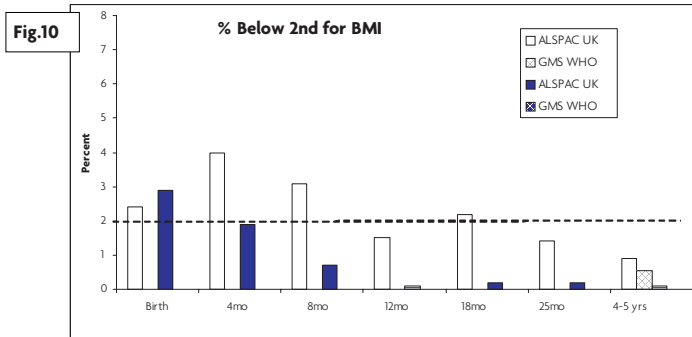
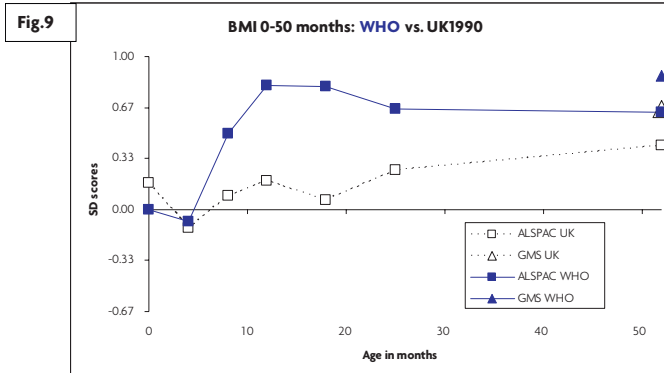
### Weight: Breastfed Only



## Length/Height: All Children



### BMI: All Children



## CONDITIONAL WEIGHT GAIN

The following shows the impact of using these data for longitudinal growth monitoring. As expected from inspection of the means, using WHO 2006 would greatly reduce the numbers of children who fall down through two centile spaces in weight between 0-12 months (a decline that serves as a primary care threshold for further investigation or concern).

Proportion of children crossing down through centile spaces from birth NB one centile space = 0.67 SD.

Changes in Weight SD scores were adjusted for baseline (i.e. conditional on birth weight)

### Percentage of all children with relative weight loss 0-4 months:

0 to 4 months	ALSPAC		GMS	
	UK	WHO	UK	WHO
>1 centile space	22.5	29.3	16.5	23.4
<b>&gt;2 centile spaces*</b>	<b>7.3</b>	<b>8.8</b>	<b>3.5</b>	<b>5.0</b>
>3 centile space	1.1	1.5	0.6	0.8

### Percentage of all children with relative weight loss 0-12 months:

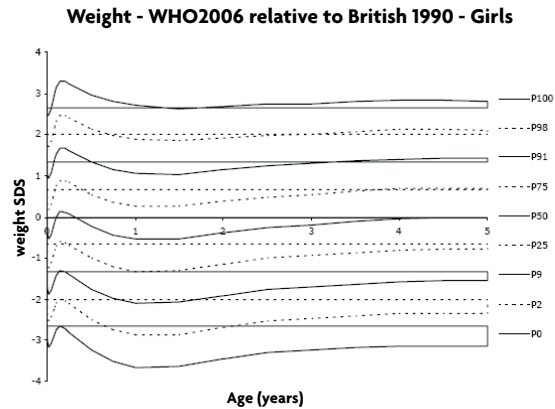
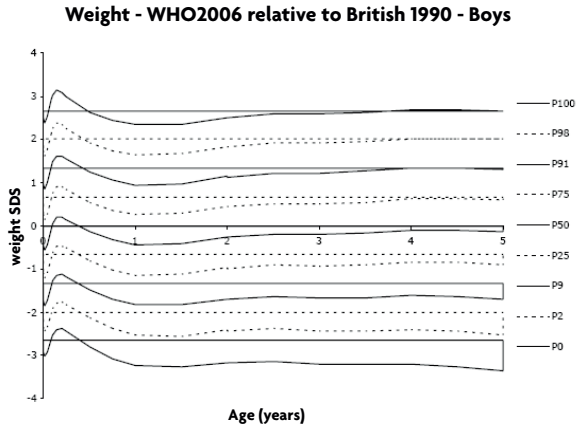
0 to 12 months	ALSPAC		GMS	
	UK	WHO	UK	WHO
>1 centile space	24.5	8.2	17.6	8.1
<b>&gt;2 centile spaces*</b>	<b>7.1</b>	<b>1.7</b>	<b>5.4</b>	<b>1.6</b>
>3 centile space	1.5	0.2	0.9	0.1

\* NB at present a fall through two centile spaces serves as a primary care threshold for further investigation or concern.

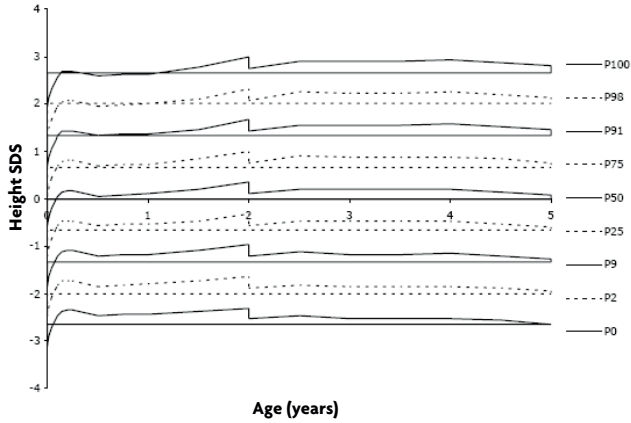
# Appendix 5

## Comparison between UK1990 reference versus WHO Growth Standards.

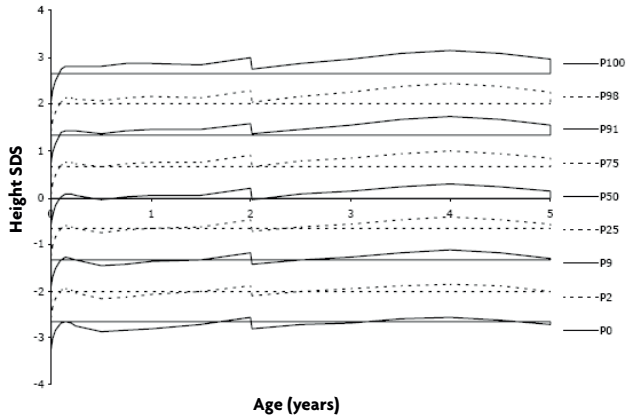
The straight lines in the figures below reflect the weight, height and BMI of British boys and girls according to the UK1990 reference and the curved lines



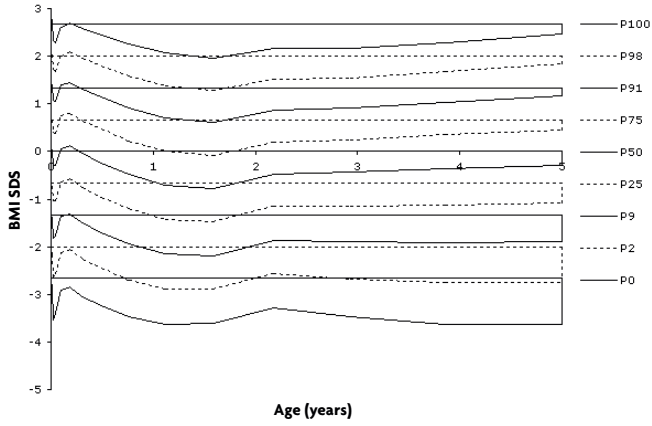
### Height - WHO2006 relative to British 1990 - Boys



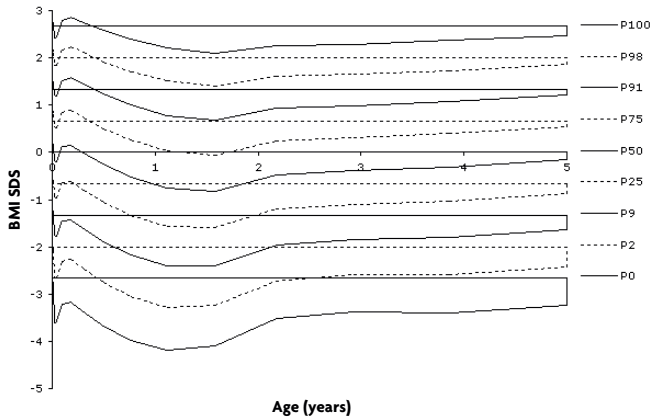
### Height - WHO2006 relative to British 1990 - Girls



**BMI - WHO2006 relative to British 1990 - Boys**

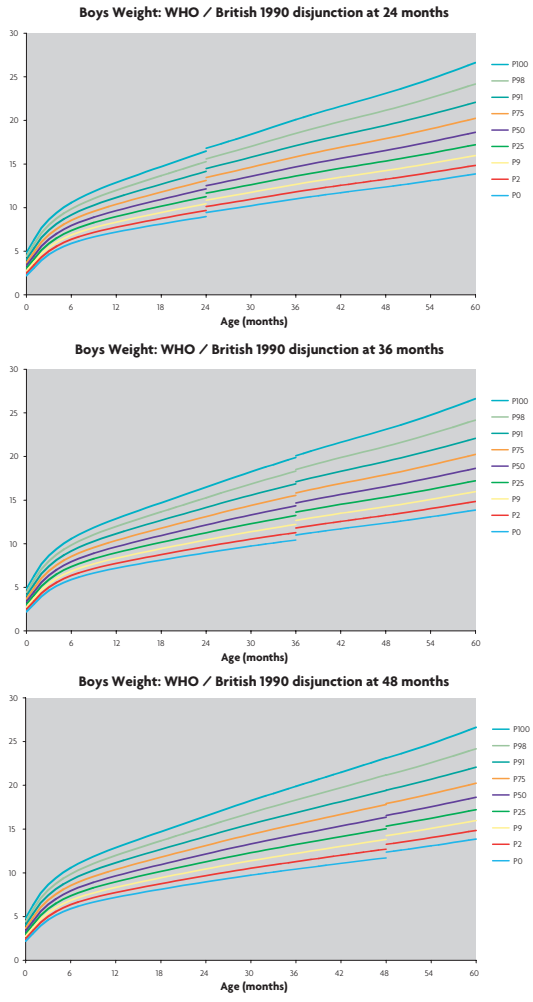


**BMI - WHO2006 relative to British 1990 - Girls**



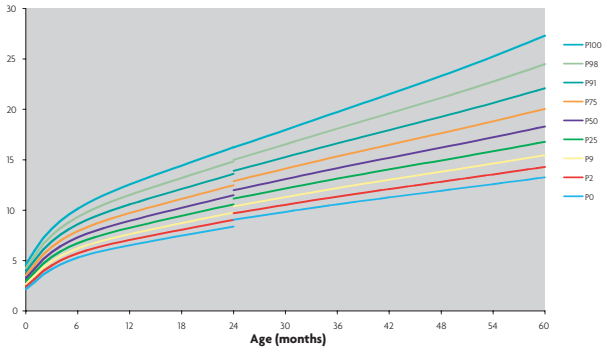
# Appendix 6

## Impact of disjunction at 24, 36 and 48 months for weight, height and BMI (boys and girls)

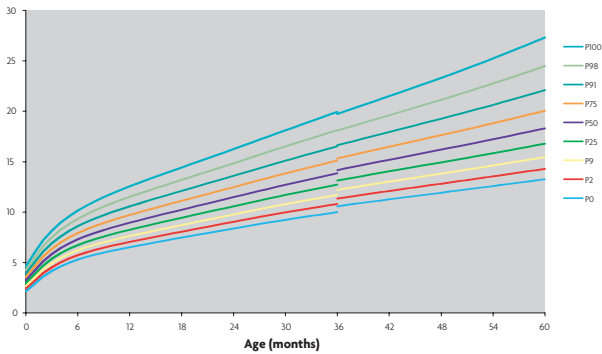




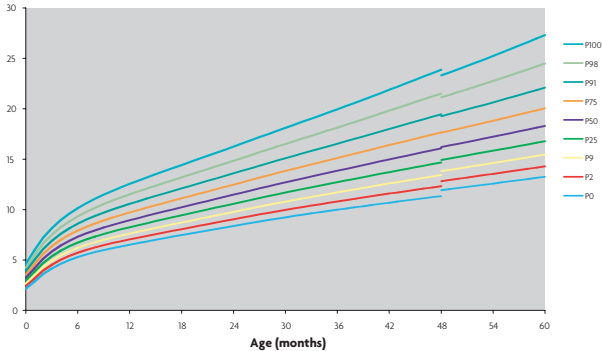
Girls Weight: WHO / British 1990 disjunction at 24 months



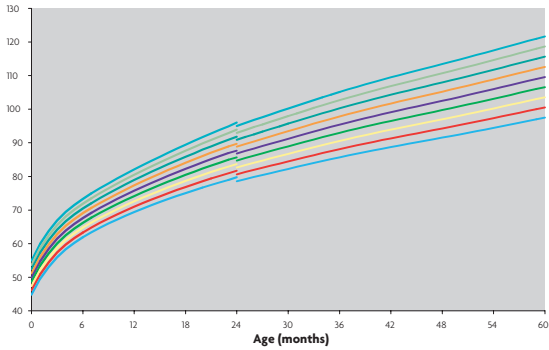
Girls Weight: WHO / British 1990 disjunction at 36 months



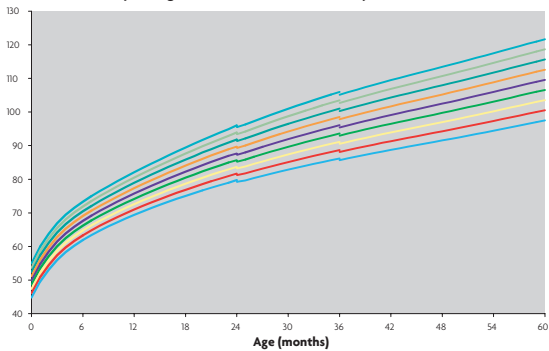
Girls Weight: WHO / British 1990 disjunction at 48 months



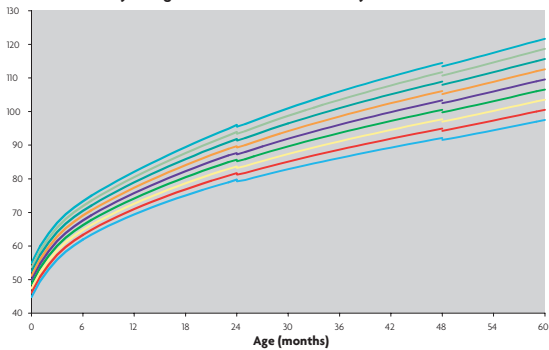
**Boys Height: WHO / British 1990 disjunction at 24 months**



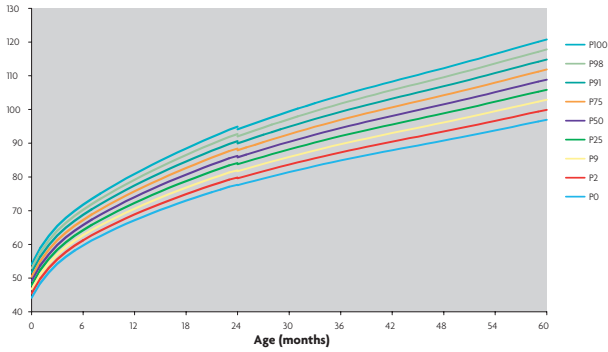
**Boys Height: WHO / British 1990 disjunction at 36 months**



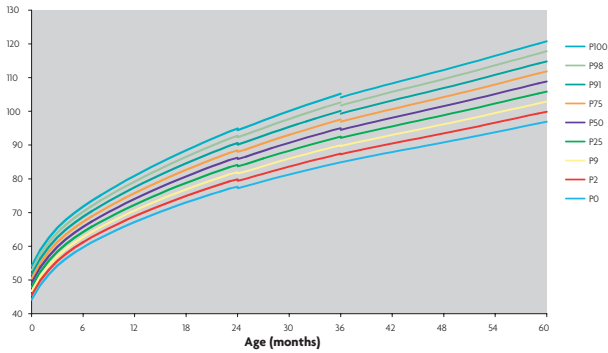
**Boys Height: WHO / British 1990 disjunction at 48 months**



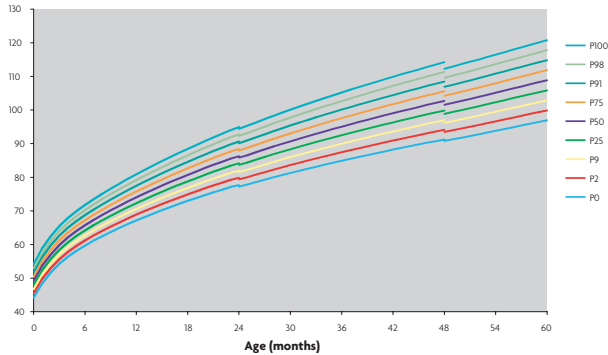
Girls Height: WHO / British 1990 disjunction at 24 months

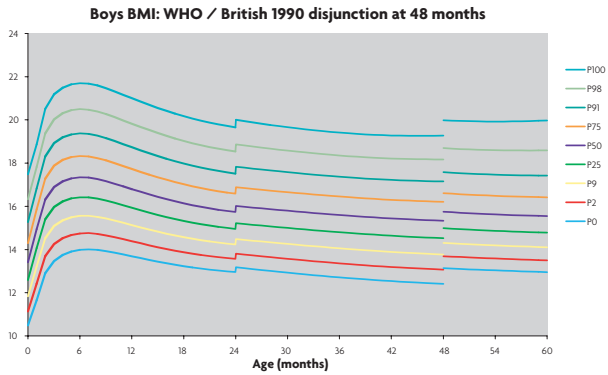
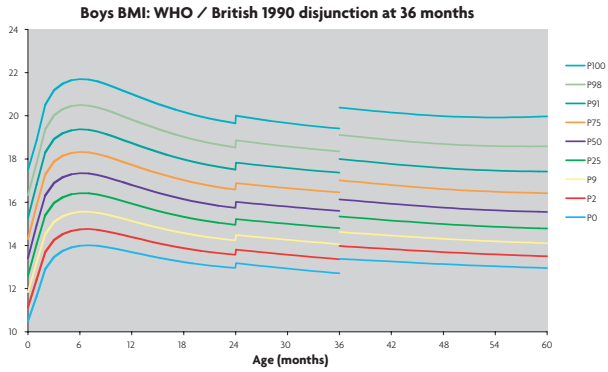
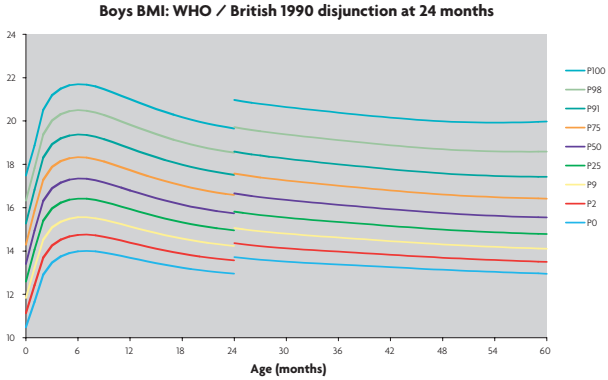


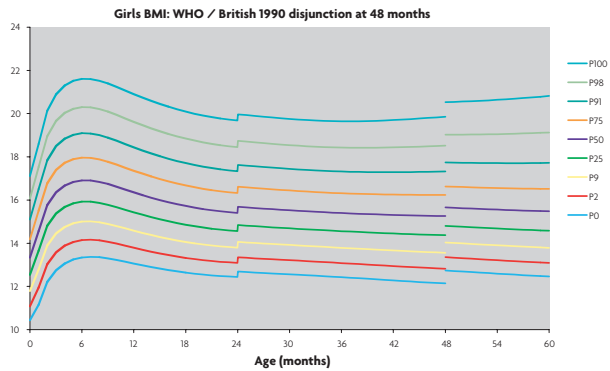
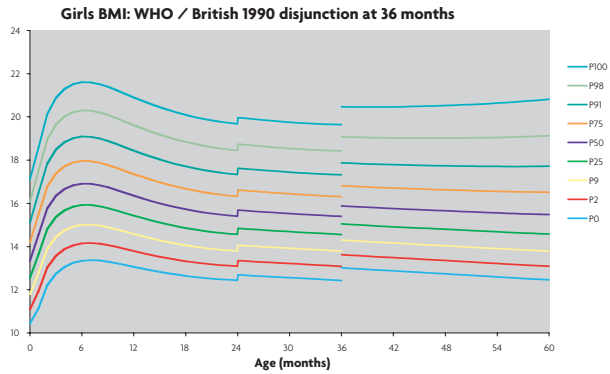
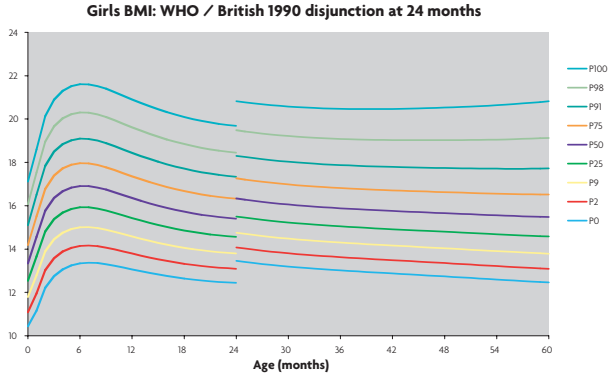
Girls Height: WHO / British 1990 disjunction at 36 months



Girls Height: WHO / British 1990 disjunction at 48 months







Application of WHO Growth

Standards in the UK

ISBN 978-0-11-243280-7



9 780112 432807

 **TSO**  
information & publishing solutions

[www.tso.co.uk](http://www.tso.co.uk)