



## Monitoring the adiposity of child populations

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# Monitoring the adiposity of child populations

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This note reports a consensus view developing between Public Health and Community Paediatrics on the different population health vs. clinical needs for measuring children in the context of the obesity epidemic.

## Background

There is a global epidemic of obesity affecting all age groups:<sup>1</sup> Its consequences are difficult to estimate, but are likely to be as great a threat to the public's health as the smoking epidemic.<sup>2</sup>

It is difficult to define a cut off level of adiposity at which children start to accumulate harm associated with obesity. In this paper we therefore refer to 'monitoring adiposity' rather than 'monitoring obesity'.

Children are an especially important group on which to focus obesity prevention because 1) the life-long risk of obesity is partly determined early in life;<sup>3-6</sup> 2) children's adiposity reflects obesogenic environments in families and communities.<sup>7</sup>

Evidence of effective interventions for reducing population obesity in children is sparse and the area is under-researched.<sup>8</sup> Health policies for tackling obesity are therefore being set using an incomplete evidence base and extrapolation from basic biological knowledge. The UK government has set a target to "*halt the year-on-year rise in obesity among children under 11 by 2010 (from the 2002 baseline) in the context of a broader strategy to tackle obesity in the population as a whole*".<sup>9</sup> In order to measure the performance of public services in meeting this target, there is a need to 1) monitor child population adiposity; 2) capture details of relevant interventions; 3) accelerate research into the causes, prevention and treatments of obesity.

In this paper we consider what might be the optimal public health strategy for monitoring child adiposity in the UK.

## Current situation

Like many western countries, for more than half a century the UK has recorded the heights and weights of children for monitoring their growth.<sup>10</sup> The primary purpose of these measurements has been for detecting children with abnormal growth patterns and referring them for appropriate healthcare; the secondary purpose has been for public health surveillance. A public health measure of adiposity from these data, the mean body mass index (BMI), is a useful measure of population adiposity.<sup>11</sup>

Screening of children for growth retardation has been rationalised in the UK recently to bring practice in line with accepted screening criteria.<sup>12</sup> As a result, many localities are reducing the number of measurements they take routinely of all children. In a postal survey of English Primary Care Trusts (PCTs) in September 2004, with a 78% response rate, we found that: 96%

routinely recorded heights and weights in the parent held child health record; 78% measured infants between 6 weeks and 8 months, 47% measured children between 1.5 and 2 years; 41% between 3 and 3.5 years; 76% at infant school entry (around 5 years); 94% of pre-school measurements were taken by health visitors; 92% of infant school entry measurements were taken by school nurses; 78% of records were sent to a child health database; 15% of PCTs produced or were planning to produce public health reports from their local database of children's heights and weights.

The appropriate reduction of measurement of children for screening for growth retardation leaves a gap in the data available for public health monitoring of adiposity. The public health services, however, did not use these data systematically in the 1990s, when the emergence of the obesity epidemic in children could have been characterised sooner than it was.<sup>13</sup>

Local services need guidance on measuring children because current policies are unclear. The National Service Framework (NSF) for children, young people and maternity services mentions monitoring of height, weight and BMI at school entry only.<sup>14</sup> The NSF and related literature about clinical needs for measuring children do not cover the public health requirements for monitoring the obesity epidemic.<sup>12;14</sup> In this paper we bring the two contexts together.

## **Requirements of a monitoring system**

We have identified the following requirements for monitoring child population adiposity:-

### **A) Measurement**

#### **A 1) Adiposity measurement**

BMI (weight for height as kg/m<sup>2</sup>) is the easiest and arguably least intrusive measure of adiposity. Skin fold thicknesses and/or body circumferences allow intra-abdominal or visceral fat mass to be differentiated from total fat mass, which gives more accurate measures for predicting known risks of adverse outcomes from obesity at the *individual* level.<sup>15</sup> At the *population* level, BMI is adequate for monitoring adiposity in pre-pubertal children, provided it is standardised for the growth proxies of age and sex.<sup>16-18</sup>

Weighing scales used for medical purposes must comply with EU Directive 90/384/EEC, which requires certification. For population purposes they should be of types approved by the Medical Devices Directorate (MDD), carry the CE mark and meet the Non-automatic Weighing Instruments Regulations class III (NAWI III) specification. There are a number of makes and models that meet this specification. The more sophisticated ones will calculate BMI if the height is entered, but these should not be necessary as only height and weight need be recorded. It is a requirement that the scales are maintained to meet the specification.

Suitable certified devices include Seca 862, Tanita WB100 and Marsden MPMS 200, which cost around £200 to £250 each. The definitive height measuring instrument is the Leicester Height Measure, which costs approximately £60.

More accurate measures of body composition are available but are difficult to collect, more invasive or intrusive, or use under-developed/studied technologies. Among the promising technologies are bio-impedance sensors and algorithms built into weighing scales – this requires epidemiological validation. At present such devices are not suitable for population monitoring purposes.<sup>19;20</sup>

## **A 2) Contexts and personnel for measuring**

Our survey found that almost all current weighing and measuring of children is done by health visitors and school nurses. We detected concern from school nurses over recording BMI in children in the absence of effective interventions to offer the obese child. Hall and colleagues have raised valid concerns over measuring children for screening purposes in the absence of evidence-based interventions to offer screen-positive cases.<sup>12</sup> Screening criteria, however, do not apply to public health surveillance or programme monitoring. Furthermore obesity interventions to promote healthy eating and physical activity are rationally health giving, with minimal health risks. A number of PCTs reported that they were planning services for clinically obese children as a continuum of planning public health interventions to slim overweight children and communities – this can be confused with inappropriate screening and referral pathways from public health into clinical services.

Health visitors and school nurses have broad roles that include both clinical and public health components. The historical context for measuring children in health visiting and school nursing was detection of failure to thrive (falling below centiles on growth charts) – this can create professional dissonance as the main need for height and weight measurements is now population surveillance of adiposity (exceeding centiles on growth-adjusted BMI charts). Furthermore, this workforce is stretched and the roles of health visitors and school nurses are under review. In ad-hoc interviews with these professional groups we found disagreement over whether or not they should continue to measure children, with most front-line staff supporting continuation but their leaders seeking re-deployment to clinical tasks.

New approaches to surveillance of childhood BMI are emerging at PCT and Local Authority levels in collaboration with local schools. Some of these initiatives are purely surveillance whereas others combine health promoting or other educational activities with measurement. They tend to use health professionals or classroom assistants to take the measurements. Where school staff are involved in measuring, their participation is likely to be voluntary; the success of this partnership between the health and education sectors will depend upon a motivational approach, at the highest levels, over the shared problem of obesity in children.

## **A3) Ages to target**

BMI starts to become useful around 2 years of age, when standing height can be measured properly. If public health interventions can influence early life determinants of obesity then the effects should be measurable by 2 or 3 years of age. We found that just under half of the UK PCTs collect pre-school heights and weights, but that this practice is stopping in some localities in response to guidance to restrict child growth surveillance to infant school entrance (5 years) and transfer to junior school (11 years).<sup>12</sup>

Adiposity surveillance plans should start to consider the important of pre-school measurements because 1) evidence is emerging that infant weight and length gain predict later obesity<sup>6;21</sup>, and 2) 5 years is too long to wait for evaluations and research on interventions that might prevent obesity early in life.

## **A4) Population coverage and measurement error**

The minimum sample size required to detect, with 80% statistical power, a difference that is equal to the annual rise in standardised BMI in young children over the past fifteen years is approximately 6,000; aggregating up to an observation period of three years takes the sample size down to 2,500.

Considering the large sample sizes required, the difficulty of achieving random sampling, and the potential for introducing systematic errors through non-random sampling: If monitoring is to be carried out at the level of the smallest population at which a public health intervention might be introduced, for example a school, then there is no case for a sampling approach to BMI in children – all children need to be monitored at agreed ages.

If the comparison of population BMI is made between Local Authorities (or the expected merged PCT populations in 2006), which is relevant to current UK targets in Local Delivery Plans (LDP), there is still no statistically valid way to sample and provide robust comparisons.

We have found through analysis of measurements from English sources of routinely-collected child heights and weights that measurement variation reduces following training on measurement technique (typically from the Child Growth Foundation). Technologies can be used to minimise the errors but observer differences might remain. If one or two observers were employed at each PCT or Local Authority to run district-wide BMI surveillance then the statistical comparison of BMI at district level could be confounded by inter-observer differences. Ironically, the current situation of multiple observers per district might provide valid district comparisons of BMI if the observer biases are distributed evenly across districts. National training schemes and standardised measuring equipment could minimise the bias.

## **A5) Consent**

Specific consent is not normally sought by health visitors and school nurses when they measure children, and parents can opt out of these examinations on behalf of their children. Non-clinical public health professionals seeking to measure children would require specific opt-in consent from parents. An opt-in surveillance scheme would be slower and more expensive to administer than an opt-out alternative. The place of public health measurements in clinical contexts needs to be clarified in respect of legislation (for example Section 60 of the Health and Social Care Act, 2001) and public expectation.

## **B) Data capture and management**

### **B1) Data capture**

Accurate, efficient capture of height and weight into electronic records is achievable through technology. Some observer and all transcription errors would be eliminated by using measuring equipment connected directly to electronic records, leaving the observer role as identifying the child interactively against electronic records and helping the child to assume the correct position and posture for the measuring equipment to work properly.

Our survey found that almost all height and weight data were captured on paper before being entered by clerk into a database. A common recording and/or transcription error is inconsistency of the weight unit as grams or kilograms.

In epidemiological use we find that between 2% and 9% of routine height and weight records from child health information systems have to be cleaned out. Heights are cleaned out more often than weights. The single most important improvement in data capture for BMI surveillance is likely to be the adoption of a standard height measure that does not require complex setting up – we recommend the Leicester instrument.

## **B2) Data security and confidentiality**

Protocols for maintaining the security and confidentiality of clinical data are established in most healthcare organisations. The costs of managing information systems to required security standards such as BS7799 are high. By using NHS clinical information systems the public health service in the UK avoids the cost of creating parallel IT infrastructure.

Child heights and weights could be collected in community settings via measuring devices connected to a notebook or handheld computer. The data could be transferred securely to a central database using virtual private network technology over wireless Internet.

Confidentiality and privacy can be protected at the analysis stage by removing individually identifiable data or encrypting them (pseudonymisation) if they are required for record linkage.

## **B3) BMI disclosure**

In order to minimise the risk of stigma, the height and weight should not be translated to BMI at the point of measurement. If a parent demands to know the BMI of their child then the BMI combined with a tailored explanatory note could be generated by a central system and emailed to the relevant GP.

## **B4) Data cleaning and standardisation**

Prior to analysis, records with incomplete or implausible data are removed. This is the data cleaning process and it should be consistent across all datasets compared. Local variations might be required, for example where an unusual value has been used to signify missing data.

Child height and weight data need to be standardised for growth if populations with different age/sex structures are to be compared. A typical standardisation and cleaning process is as follows:-

1. Remove incomplete records.
2. Examine the distributions of measurements for over-represented values that might be undeclared missing data values and remove those records.
3. Calculate decimal age from date of examination and date of birth.
4. Calculate standard deviation scores (SDS) for heights and weights using decimal age and sex specific values, with interpolation as required, from an appropriate reference population such as the 1990 British Growth Reference updated in 1996.<sup>22</sup>
5. Remove records where standardised heights and weights that are beyond a given range, say five standard deviations from the mean, i.e.  $SDS < -5$  or  $> 5$ , attributing these observations to error.
6. Calculate BMI and standardise these values for age and sex, for example using the 'adult equivalent BMI' values of the International Obesity Taskforce.<sup>16</sup> An alternative is to use BMI SDS, classifying overweight above the 91<sup>st</sup> centile ( $> 1.70$ ) and obese as above the 98<sup>th</sup> centile ( $> 2.33$ )<sup>23;24</sup> The choice of standard is less important than using a single standard universally: As obesity is a global problem, the IOTF definition is a logical choice as it enables international comparisons. Furthermore, when comparing different groups and time periods, it is essential to consider population mean BMI as well as proportions classified as obese or overweight.

Data cleaning and standardisation functions could be made available as web services maintained by a national reference centre experienced in child obesity epidemiology and informatics.

## **B5) Data integration or record linkage**

Given that obesity has many determinants and consequences, it is not surprising that its epidemiology is complex and evidence of effective interventions to reduce it is sparse. The epidemiology essential for building the evidence for tackling obesity requires linkable data. The linkage applies both within individuals (e.g. length gain in infancy) and from individuals to populations (e.g. area-based deprivation score derived from postcode).

Longitudinal linkage of records within individuals is particularly important for monitoring the overweightness and obesity that is persistent (i.e. not 'puppy fat').

Given appropriate information systems, record linkage can be performed without releasing items, such as postcode with date of birth, which might identify individuals indirectly.

## **C) Information and knowledge management**

### **C1) Profiling populations**

Childhood obesity profiles for monitoring localities can be presented in different ways, for example 1) mean SDS BMI; 2) proportions classified as overweight and obese; 3) a trend summary derived from an appropriate statistical model; or 4) a distance from target statistic – all with 95% confidence intervals.

If profiling is triggered centrally then localities might need the opportunity to make corrections due to exceptional circumstances such as a delay in completing data collection.

A national information system could facilitate benchmarking of localities.

### **C2) Evaluating interventions**

The facility to flag children, schools and communities as taking part in an anti-obesity intervention, and to register details of the intervention, could help to build the sparse evidence base quickly. If all such interventions are registered routinely then natural control groups might be identifiable in many cases.

Best practice identified through evaluations of local initiatives could be disseminated via a national web-portal to support the people monitoring child adiposity at the local level.

Feedback of children's BMI to parents, as recommended by the House of Commons Health Committee,<sup>25</sup> is an intervention that is best studied in a formal trial, because it might cause harm. For interventions where there is negligible concern over harm, randomised controlled trials or at least naturally controlled experiments should be sought.

### **C3) Research**

Research is part of public health practice; it is sometimes carried out in collaboration with academic units. Data might be shared with academics under research governance. Alternatively, academics with honorary NHS contracts as public health professionals or clinicians might analyse data in professional roles under NHS information governance, typically as audits of anonymised records.

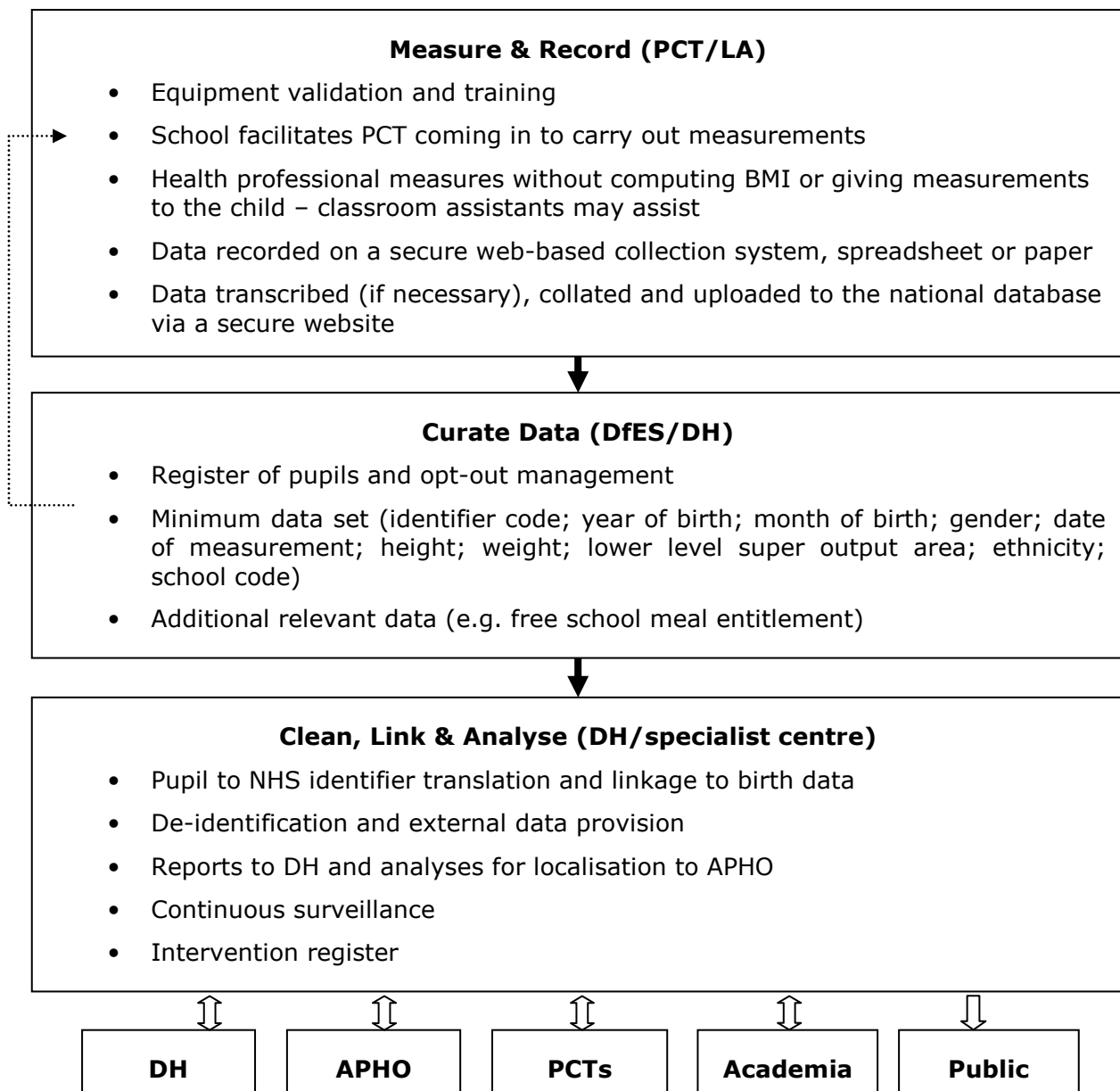
## Roadmap for development

We envisage two phases of development of a monitoring system for child adiposity. Phase I is designed to meet the immediate performance management needs relating to the child obesity PSA target; Phase II requires the universal health record to be in place and for its public health uses to be defined.

### Phase I: Schools and PCTs

Guidance is issued to PCTs to 1) discourage unproven screening activities such as sending individual BMI measurements home to parents; 2) advise on minimisation of stigma associated with being measured; 3) encourage local initiatives to continue; 4) advise on the minimum number of age groups to monitor; 5) recommend standardised measuring equipment; 6) recommend measurement training and quality assurance methods; 7) inform localities about national services for adiposity intelligence that are being developed.

The following diagram outlines a basic monitoring system around the school setting:-

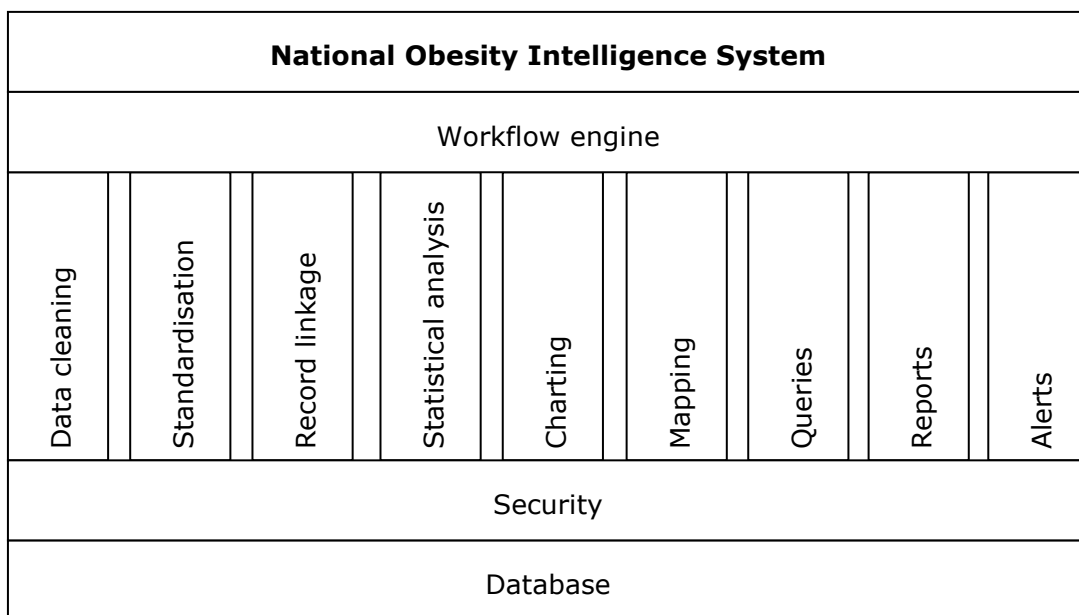




PCTs and LA partners would be responsible for measuring and recording child heights and weights – they should provide at least two school measurements (at infant school entry and transfer to senior school), and should aim to provide one pre-school measurement between 2.5 and 3.5 years. In order to avoid stigma, BMI should not be computed in school settings, instead the raw height and weight data should be recorded without revealing them to the child. If a parent subsequently demands to know the BMI then a tailored report could be generated via the national database and sent directly to the GP. Bulk purchase and distribution of the Leicester height measure should be considered – this would probably be the single most effective means to improve data quality. Prior to this, a national survey of existing equipment is required.

The PCT/LA would also be responsible for recording the data and uploading them to the storage authority via a secure website, email or other electronic means. Until such time that measuring equipment is linked automatically to a central database, PCTs/LAs in each locality need to arrange capture of data and uploading to a central facility, which could be achieved via a secure website. The National Pupil Database (NPD) would be convenient for roll-call and opt-out management in schools, therefore any national repository of height and weight measurements from schools should link with NPD. Beyond a core/minimum dataset of measurements and demographics, there are additional data in NPD which are important for policy-relevant research and service-monitoring; these include ethnicity, first language, free school meal eligibility, looked-after status, provision for special educational needs, and educational attainment. A clear framework of information governance needs to be established between the health and education sectors for sharing linkable child records whilst using them anonymously to tackle obesity.

The analysis centre would be responsible for cleaning the data, linking to other records such as birth weights, running continuous surveillance, providing reports, liaison with the academic community and maintaining a register of anti-obesity interventions in order to foster evaluation and interventional research. In order to link the basic height and weight records from schools with NHS-curated data such as birth weights, the analysis centre would need to link with an agency that holds a translation table between NHS Numbers and identifiers for school pupils. The proposed Information Sharing Index between the Department of Health and the Department for Education and Science might provide the translation – this is based on a national child reference number generated by the Department for Work and Pensions. The analysis centre should aim to develop secure web-based obesity intelligence services as outlined in the diagram below:-



Some basic web-based data cleaning and reporting tools for child adiposity monitoring are being developed at <http://www.phcalc.man.ac.uk/childobesity>

## Phase II: Electronic Health Record

As the NHS National Programme for IT develops the cradle to grave electronic health record, it will become the natural place to store child heights and weights.

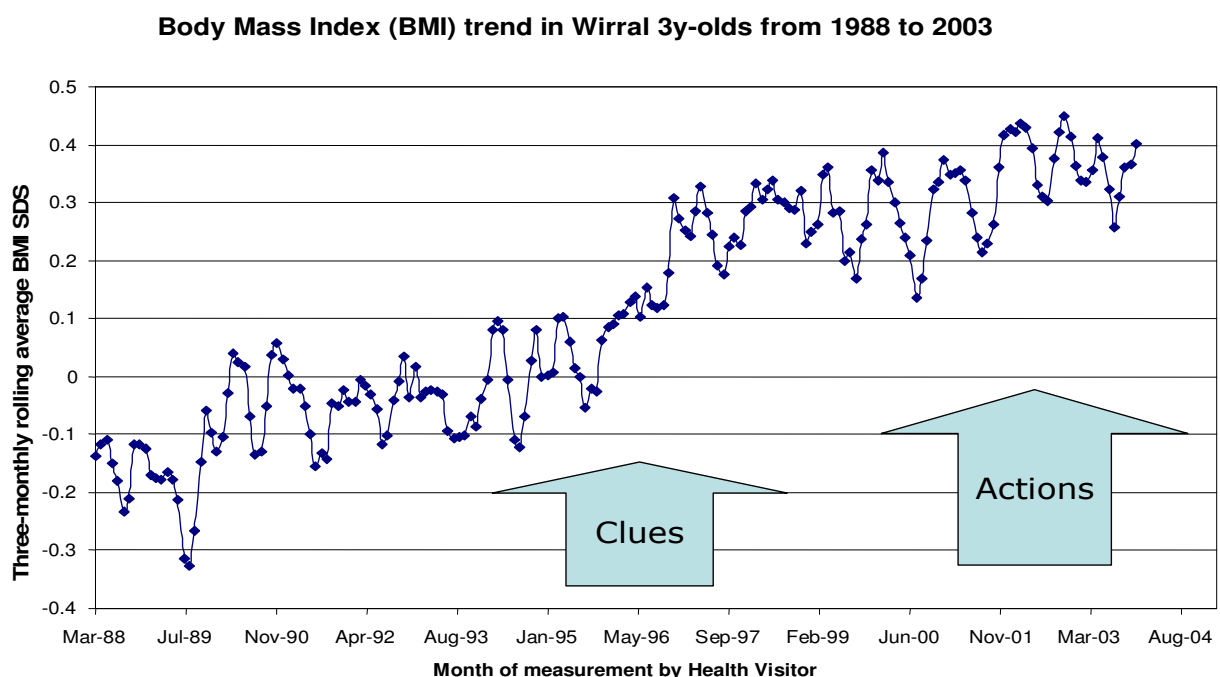
Some of the current child health information systems hold large numbers of historical anthropometric data which might not be transferred to the replacement universal record – in this case the analysis centre could archive the data for research purposes.

The Secondary Uses Service (SUS) is developing ways for authorised personnel to access pseudonymised clinical data for purposes other than direct clinical care. Child adiposity monitoring is likely to fall into this category. The phase I developments should be made compatible with the emerging SUS services so that the transition from phase I to II is efficient.

## Discussion

We reported a gap of around 6 years between statistically significant signs of rising childhood obesity and the public health response to this in England (see figure 3).<sup>13</sup> If routinely-collected child health data had been used for public health surveillance then a more timely response to the obesity epidemic might have been made.

Figure 3: Signs of an obesity epidemic apparent in Wirral pre-school children from the mid-90s



SDS = standard deviation score from 1990 British Growth Reference charts – adjusts for age and sex of the child

In December 2004 the House of Commons Select Committee on Health recommended that all UK school children should have their BMI assessed annually and the result sent to parents.<sup>25</sup> We think this is worthy of research, however, screening of this type should not be deployed en masse until such research has been carried out. The problems and questions that need to be investigated are: 1) Parents can not currently be offered interventions that are known to be

effective in slimming children – but what is the correct balance between the right to have information and the usefulness of the information?; 2) BMI is not a reliable screening tool for individual obesity – but is it good enough in certain contexts?; 3) The measuring process could lead to stigmatisation and unhelpful medicalisation of the large social problem of obesity – but what is a reasonable balance between the public health need for information and the speculative risk of harm from the stigma of being measured?

We have presented a two-stage model for monitoring childhood adiposity: This provides the performance statistics required to manage national targets whilst preparing for a possible transition to the universal health record in the future.

We see engagement with the academic community and stimulation of research as extremely important functions of the child adiposity monitoring system, as obesity policy is being set in the absence of evidence about complex causes and effective population-level interventions.

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