Journal of Human Nutrition and Dietetics (1995), 8, 417–428

Measurement of diet in a large national survey: comparison of computerized and manual coding of records in household measures

G. M. Price, A. A. Paul, F. B. Key, A. C. Harter, T. J. Cole, K. C. Day and M. E. J. Wadsworth*
*MRC Dunn Nutrition Unit, Cambridge and *MRC National Survey of Health and Development, London, UK*

A diary method using household measures was employed to obtain dietary records in a large national prospective survey and a computer program, DIDO (Diet In Data Out), was designed for direct entry of the diaries. The accuracy of this computerized coding system was examined alongside that of the manual coding used for a similar diary in a previous wave, 7 years earlier, of the same survey. Accuracy was assessed by analysis of the errors in the coded and checked records by stringent re-checking of nominal 2% random subsamples of the diet diaries coded by each method. The mean time to code and check each of the 2086 7-day records in the whole survey using DIDO was 58 minutes (SD 30) compared with reported results of 1–4 hours for manual methods. The mean error rate of computerized coding and checking with DIDO was 2.3% (SD 2.1; range 0–8.9) per diary in the subsample. Correcting these mistakes made insignificant changes to the calculated mean energy and nutrient intakes for the subsample. The percentage of individuals changing to an adjacent third of nutrient distribution after correcting unambiguous errors ranged from none (for alcohol) to 11% (for carbohydrate and calcium intake). The mean error rate on a similar subsample of diaries from the earlier survey which had been coded manually was significantly higher at 5.9% (SD 4.1; range 0–17) per diary. Emphasis is laid on the importance, in coding, of dealing with ambiguities in the subjects' records, since this can affect the accuracy and the precision of the nutrient results obtained. We conclude that the DIDO coding method has the advantages of greater accuracy, speed, consistency and efficient data handling, and affords greater data accessibility for checking, compared with manual systems.

Key words: dietary surveys, coding methods, computers, household measures

Introduction

There is a continuing need for epidemiological studies of disease and health which include measurements of diet. The MRC National Survey of Health and Development (NSHD) reported here is an ongoing study of the lives of a large birth cohort now in middle-adult life and living in all parts of England, Wales or Scotland. It was intended to collect dietary information in the 1982 and 1989 waves of this survey for the study of diet (a) in relation to disease risk status as indicated, for example, by blood pressure, respiratory function, smoking

Correspondence: Dr G. M. Price, MRC Dunn Nutrition Unit, Downhams Lane, Milton Road, Cambridge CB4 1XJ, UK.

and obesity; (b) for future retrospective use in studies of mid-life indicators of risk for health problems in later life; and (c) to assess stability and change in dietary habits in relation to earlier factors such as social class and education.

The dietary information was required to be as comprehensive and flexible as possible in order to fulfil these aims. Practical and logistical constraints included the wide geographical scatter, the large population ($n = 3854$), the necessity for the assessment to be made or introduced by a research nurse as a small part of a single home interview and the need to maintain the co-operation of the subjects in order to maintain good response rates in future data collections.

The first dietary measurement in these subjects was made in 1982 by means of a 7-day diet diary in which all food and drink consumed was recorded by the subjects in household measures (Braddon *et al.*, 1988). The information was converted into food codes and weights by manual coding, a laborious process and not easy to check on such a large scale.

For the subsequent data collection in 1989 the diet diary was modified, mainly by the addition of a set of food photographs to aid portion description. This paper describes the diary and the computerized coding system developed for the second wave, and reports the accuracy of this coding method in comparison with that of the manual coding used in 1982. Sheppard *et al.* (1990) have previously published an analysis of error rates of a manual and their own computerized coding method, indicating fewer errors with computerized coding. The present paper includes, in addition, an analysis of the nutrient intakes before and after correction of the errors found in a subsample of diaries, and comments on the management of problems of interpretation encountered in coding.

Methods

Study population

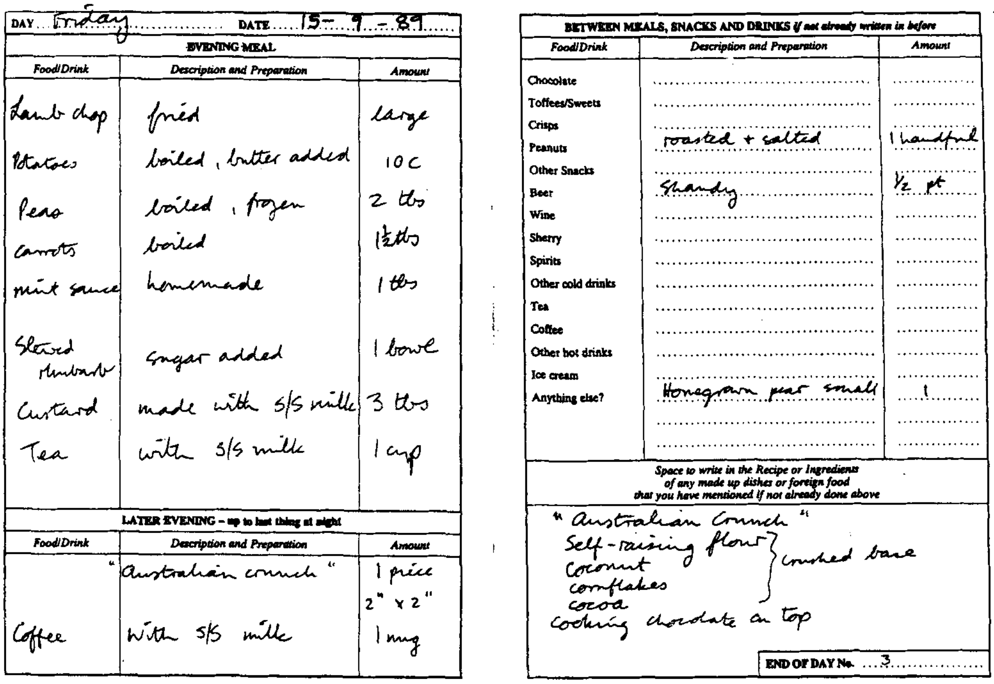
The MRC National Survey of Health and Development is a prospective national birth cohort study of a social class-stratified sample ($n = 5362$) of all those born in England, Wales and Scotland in the first week of March 1946. A wide range of information on social, psychological, medical and biological topics has been collected on 19 occasions from infancy to adult life (Wadsworth, 1991). Seven-day dietary information was collected for the first time in 1982, when the subjects were aged 36 years (Braddon *et al.*, 1988). In 1989 at the most recent data collection, 3262 survey members, then aged 43 years, were successfully contacted. These were 85% of those alive (7% of the cohort had died), resident in Britain (11% live abroad) and not a refusal (10% had refused); in most respects the sample remains representative of the native-born of this age (Wadsworth *et al.*, 1992).

Dietary data collection

At the 1982 interviews research nurses made anthropometric and other measurements and administered a questionnaire on survey members' health, employment and social circumstances. Each interview concluded with a 48-hour recall, recorded in household measures, of all food and drink consumed by the subject. This record was entered in the diet diary by the nurse, thus demonstrating the method and the detail required. Nurses received instructions on the use of the diaries during their training. Each subject was then asked to keep the diary for the subsequent 5 days and to return it by post.

In the 1989 wave the interview nurses recorded a dietary recall for the immediate past 2 days, and the diet diary was left with the subject to fill in over the subsequent 5 days and return by post, as in 1982. A carbon copy of the 2-day retrospective record was retained to ensure that at least some dietary information was obtained for every survey member visited. There was no further contact with the subjects, in line with a policy of confidentiality and minimal invasiveness, especially with a view to enhancing the likelihood of future contacts.

The main part of the diary comprised seven spaces for each day in which to record meals and between-meal snacks, a reminder section about any other snacks and drinks and a space in which to write recipes (Fig. 1). This was prefaced with 66 examples (fewer in 1982) of how to describe foods in terms of their preparation and quantity. In 1989 the diary included black-and-white photographs of three



DAY Friday DATE 15 - 9 - 89

EVENING MEAL

Food/Drink	*Description and Preparation*	*Amount*
Lamb chop	fried	large
Potatoes	boiled, butter added	10 C
Peas	boiled, frozen	2 tbs
Carrots	boiled	1½ tbs
mint sauce	homemade	1 tbs
Stewed rhubarb	sugar added	1 bowl
Custard	made with S/S milk	3 tbs
Tea	with S/S milk	1 cup

LATER EVENING – up to last thing at night

Food/Drink	*Description and Preparation*	*Amount*
	"Australian crunch"	1 piece 2" x 2"
Coffee	With S/S milk	1 mug

BETWEEN MEALS, SNACKS AND DRINKS *if not already written in before*

Food/Drink	*Description and Preparation*	*Amount*
Chocolate		
Toffees/Sweets		
Crisps		
Peanuts	roasted + salted	1 handful
Other Snacks		
Beer	Shandy	½ pt
Wine		
Sherry		
Spirits		
Other cold drinks		
Tea		
Coffee		
Other hot drinks		
Ice cream		
Anything else?	Homegrown pear small	1

Space to write in the Recipe or Ingredients of any made up dishes or foreign food that you have mentioned if not already done above

"Australian Crunch"
Self-raising flour
Coconut
cornflakes
cocoa
} crushed base
Cooking chocolate on top

END OF DAY No. 3

Fig. 1. Example page of the 1989 diet diary, showing the second half of a day's record.

portion sizes each of 15 common dishes to aid descriptions of quantities. Most of the photographs had been used previously by other investigators (Edington *et al.*, 1989) although a number were added for the present study.

Coding of dietary records

Information from the 1982 diaries had previously been coded manually into food codes and weights by Braddon *et al.* (1988). Coding at that time was achieved by coders consulting a list of foods to obtain the relevant food code and also a portion weight in grams most suitable to the portion description given by the subject. Codes and weights were written onto coding forms which were later typed into a computer file by a data input clerk. The 1982 food records were not checked individually, but a series of computer checks for maximum and minimum weights was run on the computer files of codes and weights for the whole 1982 survey and corrections made to the computer files, before analysis and publication of the nutrient results (Braddon *et al.*, 1988). Food codes were from standard tables (Paul & Southgate, 1978) and recipe calculations, both published (Wiles *et al.*, 1980) and unpublished (Braddon *et al.*, 1988). Portion weights were derived mainly from studies conducted at the Dunn Nutrition Unit (Nelson, 1983; A. E. Black, pers. comm.) and also from weights of manufactured products given on packets.

The 1989 diet diaries were coded and checked using a specially developed direct entry computer program, DIDO (Diet In Data Out), which generates a food code and associated weight in grams for each item of food and drink recorded. The output file was exported to the Dunn's suite of programs for nutrient analysis. Food codes were from standard tables (Paul & Southgate, 1978; Holland *et al.*, 1988; Holland *et al.*, 1989), recipe calculations (Wiles *et al.*, 1980) and information from manufacturers. Portion weights were derived mainly from those given by Crawley (1988), together with data from previous weighed-intake studies at the Dunn Nutrition Unit (A. E. Black, pers. comm.) and packet weights of manufactured products.

The DIDO program was written in the C programming language to be usable on

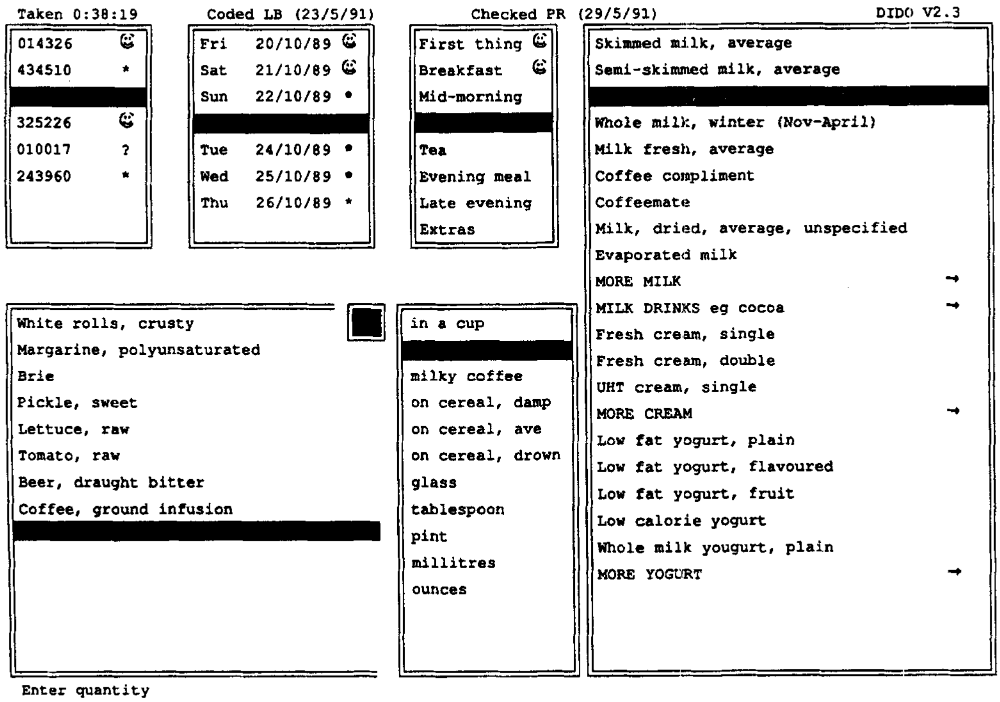


Fig. 2. A DIDO coding or checking screen showing boxes for (clockwise, from top left) subject ID, diary date, meals, food menu (database), portion size, quantity and foods coded for the current meal. The figure shows the screen during the coding of a new food item, 'whole milk (summer)': the item has been selected from the database menu and entries are being made in the 'quantity' and 'portion size' boxes. Once this has been done these two boxes disappear from their superimposed 'pop-up' position above the 'coded foods' box, and the new food name is added to the list of coded foods. Asterisks denote presence of food coded under that heading, question marks point to one or more queries against those foods and 'smiley face' marks indicate that all entries under that heading have been checked. Similar symbols marking the individual food items in the 'coded foods' box are obscured temporarily by the 'portion size' box. Arrows in the 'food menu' box denote the presence of sub-menu(s) for the indicated food category.

IBM-compatible personal computers by operators having minimal nutritional or computer training. The program was designed around a hierarchical food menu structure and comprises three different modes, namely 'coding', 'checking' and 'maintenance', which are described below.

Fig. 2 illustrates a typical screen presentation in 'coding' or 'checking' mode. The main food database menu lists 20 food groups, each leading to several levels of sub-menus. A food item can be chosen from the database by progressing through the menu structure, by using keyword string searches or by typing in food codes. A predefined choice of appropriate portions, to a maximum of 12, is offered for each food when selected. Household measures defined include large, medium and small portions, table- and teaspoons, cups, mugs, glasses, pints, slices, sandwich fillings, packets and individual units such as biscuits. Singles, multiples or fractions of portions can be entered. If the weight is known it can be entered directly in grams or ounces.

Maximum portion weights have been entered in the DIDO database as the maximum quantity of each food likely to be consumed at one time. If any food entry exceeds this DIDO prompts for confirmation by the coder or checker. The maximum weights were chosen to be high enough not to flag too many items so that due notice is not taken of them, yet low enough to detect as many unlikely entries as possible. As a further safeguard, the Dunn's nutrient analysis program also identifies all food weights above an assigned maximum.

Some foods in the DIDO database have menus of associated food items attached. For example, if tea or coffee is selected in 'coding' mode another menu is automatically shown, containing various types of milk and sugar. There are equivalent associated menus for breakfast cereals (milk and sugar) and bread (a selection of spreads).

On completion of coding each food item is marked by the program with an asterisk. DIDO's 'checking' mode shows the coded foods in the same presentation format as in 'coding' mode. Each food entry is checked against the diet diary by a second coder and any necessary alterations are made, before the checker replaces the asterisk with a 'checked' symbol. Fig. 2 shows asterisks and 'checked' symbols against subject IDs, dates and meals, but those marking the individual food items in the figure are obscured by the 'portion size' box which pops up in response to the selection of a food item from the database menu. The total time taken to code and check each diary is monitored automatically by the program.

The menu system can be updated in 'maintenance' mode by adding, deleting, moving or amending food descriptions, food codes, portion descriptions, portion weights or maximum portion weights. Food codes and portion weights are not shown in 'coding' or 'checking' modes but can be seen on-screen when in 'maintenance' mode. 'Maintenance' mode was not used by coders of this survey—any necessary alterations to the database were made only by the supervising nutritionist.

Coding policy in the 1989 data collection was to use 'more exact' measures wherever given by the subject (e.g. 3 oz cheese or $\frac{1}{4}$ pint, or 2 tablespoons, of milk), and in the absence of these, or of any portion size information, to use average database portions. In cases where the subject omitted a 'usual' item, such as margarine on bread or sugar in tea, a careful study was made of the rest of the diary to see whether the subject was most likely to have forgotten to write the item, in which case it would be coded in, or genuinely not to have eaten the food, in which case it would be left out. The working assumption was that most people are creatures of habit and unless there was evidence in the diary to indicate otherwise, the eating pattern of the individual was maintained.

Method of analysis of coding errors

Accuracy of the DIDO-coding and checking was assessed by analysing the coding errors after all the diaries had been coded, checked by a second coder, and a separate computer check against suggested maximum portion weights for each food code had been run. The error analysis was done on a random, nominally 2%, subsample (n = 37) which was taken (using the statistical package SPSS) from all diaries with at least 3 days' data; of this subsample 34 (92%) were 7-day and three (8%) were 5-day records. The 37 diaries were each re-checked very stringently by two experienced nutritionists, comparing the DIDO-coded version with the diary entries. Errors were documented qualitatively and quantitatively. The size of the subsample taken was a compromise between one too small to be able to make any meaningful comment and one too large to be manageable in terms of labour resources.

Each error related to the resulting food code and portion weight as a single entry. For example, if the survey member had recorded two mugs of instant coffee in a certain meal and this had been coded as two mugs of tea there would be only one error—an incorrect food code—since the two mugs constituted a single entry.

Error rates were calculated for each subject's record as the total number of errors divided by the total number of foods (food codes) entered. In theory, this calculation could be an overestimate and could lead to error rates of more than 100%, since errors could (and occasionally did) occur simultaneously in both the food code and the assigned weight (e.g. thickly spread butter coded as medium-spread margarine). Certain errors were replicated several times over the diary record (such as the wrong type or amount of milk coded with tea). Each of the replicates in these multiple errors was counted separately for the purpose of calculating error rates. The number of errors in each of several different categories was calculated for the total subsample, rather than on a 'per diary' basis, and reported in Table 2.

Ambiguities occurred in coding where the survey member did not supply sufficient information, or was thought not to have done so, such as instances of suspected omissions from a usual pattern, illegible handwriting or no information on portion size. For example, margarine or butter might have been recorded for some, but not all, bread or toast eaten. Any two coders might thus make different interpretations of the record. Ambiguities were excluded from the main error analysis. However, when 'improvements' to the original coder's interpretation could be made by the nutritionist after careful consideration of the context, the coding was 'corrected' and error rates calculated separately with these ambiguities included as errors.

Nutrient analysis was performed on both the uncorrected and corrected versions of the 1989 subsample in order to assess the significance, in terms of nutrient intakes, of the errors found on re-checking. There were two versions of 'corrected' data, namely one in which ambiguities were left 'as is' and one in which these errors were 'corrected' (as explained above) along with all the unambiguous errors.

Error rates in the manual coding of the diaries recorded in 1982 (Braddon *et al.*, 1988) were estimated in an approximate 2% random subsample ($n = 48$) of all diaries with more than 3 days' entries. This subsample comprised 35 (73%) 7-day, three (6%) 6-day and 10 (21%) 5-day records. The coding sheets were checked again manually, by the same nutritionists who re-checked the 1989 subsample, by reference to the list of food codes and portion weights originally used to code these diaries. Analysis of errors was done in exactly the same way as for the DIDO-coded diaries but the errors in the manually coded subsample were not corrected in this exercise.

Statistical methods

Comparison of the percent error rates in the 1982 and 1989 subsamples used the non-parametric Mann–Whitney test for independent samples since the data were not normally distributed and the variances of the groups were not of equal size. Differences between nutrient intakes calculated before and after correction of the errors found in the 1989 subsample were examined using the non-parametric Wilcoxon's signed-rank test for paired samples. Analysis of allocation of individual results to thirds of the original uncorrected, and the corrected, distributions was also used for this comparison. SPSS was the computer package used for all statistical procedures.

Results

Coding time

Using DIDO, coding and checking the 2277 diaries collected in 1989 took the equivalent of two full-time coders 15 months each. The mean time taken to code and check each of the 2086 7-day diaries was 58 (SD 30; median 51) minutes. Ninety per cent of the diaries were coded and checked in less than 91 minutes each. These times included the time taken to consult recipe books, regional or international food descriptions or other coders or the nutritionist. Additional time for tasks such as file transfer, backing-up, administrative maintenance (including sorting and storing diet diaries) and short breaks amounted to about 30 minutes to an hour per diary.

The 1989 diaries were coded by non-nutritionists who had, however, some biological education of at least A-level standard. They also had an interest and day-to-day experience in food preparation, which was considered more useful than any previously held computing skills. Two or three coders worked in parallel, and mostly part-time, for varying periods of employment. They were trained on their first day of work by the supervising nutritionist, with close supervision for the next few days.

Coders gained coding speed with time, reaching their plateau in 3–4 months. This was achieved, most importantly, by learning how to translate brand names into the generic names present on the computer database, which uses parts of food names as search strings to find a given food most efficiently; and how to break down recipe items into constituent ingredients. Essential operational knowledge of the DIDO computer program was gained largely in the first day of use and was not a major factor in the increase in coding speed. Information is not available on the time taken to code the 1982 diaries manually.

Table 1. Errors found in random subsamples of 1982 diaries ($n = 48$, manual coding method) and 1989 diaries ($n = 37$, coded using DIDO). Results are shown as mean (SD) per diary, both excluding and including ambiguities as errors

	Mean (SD)			
	1982 (Manual)		1989 (DIDO)	
	Ambiguities *not* included	Ambiguities included	Ambiguities *not* included	Ambiguities included
Number of foods per diary	148 (39)		183 (34)	
Number of errors per diary	8.6 (6.5)	9.8 (7.6)	3.8 (3.3)	7.4 (8.7)
Percentage error rate per diary[1]	5.9 (4.1)**	6.9 (5.3)*	2.3 (2.1)**	4.3 (4.9)*

[1]Statistical testing, using the Mann–Whitney test, was performed on the percentage error rates: error rates marked with the same superscript are significantly different from each other (*, $P < 0.01$ and **, $P < 0.001$).

Coding accuracy

In the 1982 subsample the mean error rate per diary was 5.9% (SD 4.1; range 0–17) and, with ambiguities also counted as errors, 6.9% (SD 5.3; range 0–30) (Table 1). In the subsample of 1989 diaries the mean error rate per diary was significantly lower than in 1982 at 2.3% (SD 2.1; range 0–8.9) and with ambiguity 'errors' included it was 4.3% (SD 4.9; range 0–20.2). Including the ambiguities as errors increased the mean error rates in both years, but not significantly so, probably because the variance in the subsample was also increased.

There were 35 occurrences of multiple errors in the 1982 subsample, 43% of these being duplicates and the others having between three and ten replicated errors. There were also seven multiple ambiguities with between two and 33 replicates. In the 1989 subsample there were only two instances of multiple errors, with 6 and 11 replicates, respectively. In addition there were nine multiple ambiguities. These comprised between 5 and 28 replicates, thus raising the error rates considerably for those diaries and also increasing the mean error rate for the whole subsample.

The separate maximum portion weights check on the DIDO-output file usefully identified the few gross coding errors which had not been discovered in the DIDO 'checking' mode, or even by the program's 'maximum weight exceeded' flag. There was one such gross error in the 1989 subsample: 250 g chocolate mousse had been coded as 250 average portions which, at 60 g per portion, amounted to 15 kg of mousse! It was surmised that the coders might have allowed this error past the DIDO maximum portion flag since 250 g, the recorded weight, was itself above the suggested maximum portion weight of 200 g. This gross error was corrected as an automatic sequel to coding on DIDO, so it did not appear in the error analysis reported in this paper. There were 10 such gross errors in the whole 1989 sample of more than 2000 diaries, all detected by the maximum portion weight program in the Dunn suite of nutrient analysis programs. With the benefit of hindsight it would have been better had DIDO required a second entry of any foods flagged as exceeding maximum weight during coding.

Table 2 shows a breakdown of the errors into different categories, expressed as a number of errors per 100 diaries, and the percentage of the total number of errors attributable to each category. These results show that the percentage of all errors which was associated with the estimation of portion size, excluding ambiguities, was 49.8% in 1982 and 24.5% in 1989. Erroneous assignment of portion sizes accounted for most of the difference in total error numbers between the 2 years, when ambiguities were not included, 1982 having four times the errors per 100 diaries in this category compared with 1989. The number of portion sizes which were too big was of the same order as the number which were too small in both years, but this ratio changed when ambiguities were included, in 1989 especially, in favour of portions too large.

There were twice as many incorrect food

Table 2. Breakdown of coding errors into categories in random subsamples of 1982 diaries ($n = 48$, manual method) and 1989 diaries ($n = 37$, using DIDO). Results are shown as number of errors per 100 diaries, with the percentage of all the errors shown in parenthesis, both excluding and including ambiguities as errors

	Number of errors per 100 diaries (% of all the errors)			
	1982 (Manual)		1989 (DIDO)	
	Ambiguities *not* included	Ambiguities included	Ambiguities *not* included	Ambiguities included
Incorrect date	0	0	3 (0.8)	3 (0.4)
Incorrect meal allocation	6 (0.7)	6 (0.6)	14 (3.6)	14 (1.9)
Quantity too large	235 (27.4)	252 (25.6)	51 (13.3)	249 (33.7)
Quantity too small	192 (22.4)	200 (20.3)	43 (11.2)	60 (8.1)
Missing food	106 (12.4)	127 (12.9)	97 (25.3)	97 (13.1)
Extra food	31 (3.6)	42 (4.3)	32 (8.4)	100 (13.5)
Incorrect food code	288 (33.5)	356 (36.2)	143 (37.3)	216 (29.2)
Total per 100 diaries	858 (100)	983 (100)	383 (100)	739 (100)

codes per 100 diaries in the manually coded 1982 subsample as in the DIDO-coded 1989 subsample. Detailed inspection of the reasons for incorrect food codes revealed that in 1982 most were as a result of codes chosen for a different cooking or processing form of the same food (27%), generally misguided choice of code (26%) and, apparently, remembering codes wrongly (21%). Manual coding relies to some extent on memory, since coders tend to memorize the codes of often-reported foods to avoid having to look them up each time. Examples of memory errors which were found in the 1982 subsample are: lettuce (code #606) coded as tomatoes (code #666), and vice versa; coffee (#872) confused with sugar (#843); frosted cornflakes (#1023) coded as paprika (#1223)(!), and Weetabix (#57) coded as jam tart (#87) on four separate days for the same subject. One or two of the errors could not logically be explained, namely new potatoes (#648) being coded as roast turkey (#345) and demerara sugar (#842) being coded as rump steak (#250)! It is also easy, with the manual coding system, to transpose the food code and weight as, for example, in the coding of a 52 g portion of carrots as Ready Brek breakfast cereal (code #52). Such 'slip of the pen' errors amounted to 6% of the wrong codes in 1982. Some, but not all, of these code errors would be detected in a maximum weights check. Totally incorrect food codes were not found in DIDO coding as food code numbers are not visible in the 'coding' and 'checking' modes and the possibility of entering a wrong food through transposition of code numbers is eliminated.

In the 1989 DIDO-coded subsample, excluding ambiguities, more foods were missing than were erroneously added, examples of the latter being milk put into black coffee or tea, butter or margarine put onto bread and one or more recorded foods duplicated by mistake. The number of portion weights which were too large was similar to those that were too small. Thirty-seven per cent of the errors were an incorrect food entered, although these almost always differed from the correct food only with regard to processing or method of cooking (e.g. smoked instead of fresh fish), or fat-, sugar- or alcohol content (e.g. whole-milk yoghurt vs. low-fat yoghurt, lemonade vs. low-calorie drink and beer coded mild instead of low-alcohol). The least-related incorrect food codes in 1989 were muesli instead of digestive biscuits, Rice Krispies instead of boiled rice and stewed plums instead of fresh peach.

The ambiguities in the 1989 subsample related mostly to portion sizes. Subtracting the number of errors per 100 diaries in the third from those in the fourth column in Table 2 gives the number of ambiguities per 100 diaries in each category. More ambiguities related to portions being too large (198 'errors' per 100 diaries; e.g. standard portions of milk coded for tea or coffee when the subject had written '2 teaspoons' or '1 tablespoon') than too small (17 'errors' per 100 diaries). There were also some relating to extra foods having been added (68 'errors' per 100 diaries; e.g. butter or margarine coded for bread where the subject had either never, or only sporadically, recorded usage) and to a less probable food code being chosen (73 'errors' per 100 diaries). An example of the latter is that the subject usually had not stipulated the type of milk used, but had left a clue or two which the coder had not utilised, as to the most probable milk code to use. (See the paragraph on ambiguities in the 'Methods' section, under 'Method of analysis of coding errors'.)

In terms of nutrient intakes almost all errors in the DIDO-coded subsample were minor. No significant differences were found between the mean energy and nutrient intakes calculated for these 37 subjects with the uncorrected and corrected records (Table 3). When classified into thirds of the distributions, no subject moved to the opposite third, and a maximum of three (8% of the subsample) to the adjacent third for any one nutrient, after the errors had been corrected. When ambiguities were also 'corrected' there was a significant difference in mean fat intake from the original value and one subject moved from the highest to the lowest third in terms of this nutrient. This was caused by the sporadic reporting of butter on bread by the subject, interpreted by the coder as an omission. In the original coded version there were 11 occurrences of butter throughout the diary where, after a searching study of the rest of the diary, it was decided that butter should more probably *not* have been included. The correction of this 'error' resulted in a decrease in mean daily fat intake for this individual of 31 g/d.

Discussion

Coding dietary data is time consuming, and can impose limitations on dietary studies (Edington *et al.*, 1989). In the computerized coding system described here a significant reduction in coding errors was achieved compared with the manual method. Correcting the mistakes still present made insignificant changes to the calculated mean energy and nutrient intakes. The percentage of individuals changing to an adjacent third of nutrient distribution after correcting unambiguous errors ranged from none (for alcohol) to 11% (for carbohydrate and calcium intake). Therefore, the attainment of improved coding speed and accessibility of the coded data was not at the expense of accuracy.

Coding speed

Using DIDO the mean time taken to code and check the 7-day diaries from the 1989 NSHD survey was 58 (SD 30) minutes. This is very similar to the 56 minutes reported by Sheppard *et al.* (1990) for coding and checking each of 40 7-day weighed intake records by direct computer entry, although these authors reported an extra 13 minutes per record for a manual file-editing procedure.

In contrast, Sheppard *et al.* (1990) reported that manual coding and checking and data entry took an average of 104 minutes per 7-day weighed-intake record. A review of the logistics of dietary surveys (Black, 1982) has suggested that manual coding of dietary data from typical 7-day diaries may take from about 1 hour per diary, if every food item is weighed and can be described by a single item present in food tables, to about 3–4 hours if the diary is recorded in household measures. Data entry and verification time, of about 20 minutes per diary, is additional to this. Coding of diaries recorded in household measures is expected to take longer than weighed records because coders must assign portion weights to each food as well as choose the most appropriate food code (Black, 1982).

Coding accuracy

However carefully the coding is done errors inevitably arise due to fatigue, particularly in a large-scale study such as the present one with intensive coding for many months. For this reason it is essential to perform a variety of targeted checks on the data at various stages. Our finding of insignificant differences in nutrient intakes before and after correction of errors should not be taken to indicate that there is no need to check coding: the error analysis was undertaken on coding already checked once (at least in the case of the 1989 data) and scanned for gross coding mistakes.

Direct data entry systems result in fewer

Table 3. Comparison of nutrient intakes before and after correction of coding errors found in a subsample of 37 DIDO-coded 1989 diaries. Results are also shown of nutrient intakes after correcting ambiguities as well as unambiguous errors

	Mean (SD)			Mean % difference from original (range)		Percentage of subjects changing thirds[2] after	
Nutrient	Original	Unambiguous errors corrected	Ambiguities also corrected[1]	Unambiguous errors corrected	Ambiguities also corrected[1]	Unambiguous errors corrected	Ambiguities also corrected[1]
Energy (kcal)	2068 (529)	2062 (547)	2048 (550)	− 0.5 (− 5.0 to 3.3)	− 1.2 (− 13.4 to 3.3)	3	11
Energy (MJ)	8.67 (2.22)	8.64 (2.29)	8.59 (2.30)	− 0.5 (− 5.0 to 3.3)	− 1.2 (− 13.4 to 3.3)	3	8
Protein (g)	72 (14)	72 (14)	72 (14)	− 0.4 (− 5.6 to 4.9)	− 0.5 (− 5.6 to 4.9)	3	3
Fat (g)	88 (30)	88 (32)	87 (32)	− 1.0 (− 8.4 to 4.9)	− 2.6* (− 28.4 to 4.9)	3	8[3]
Carbohydrate (g)	242 (66)	242 (66)	241 (66)	− 0.2 (− 7.9 to 4.7)	− 0.3 (− 7.9 to 4.7)	11	11
Alcohol (g)	10 (14)	10 (14)	10 (14)	− 0.1 (− 8.0 to 4.4)	− 0.1 (− 8.0 to 4.4)	0	0
'Dietary fibre' (g)	21 (7)	21 (6)	21 (6)	0.2 (− 6.4 to 5.0)	0.2 (− 6.4 to 5.0)	5	5
Calcium (mg)	912 (217)	913 (217)	909 (214)	0 (− 8.3 to 9.7)	− 0.3 (− 9.0 to 9.7)	11	16
Iron (mg)	12 (3)	12 (3)	12 (3)	− 0.8 (− 13.4 to 4.8)	− 0.8 (− 13.4 to 4.8)	8	8
Vitamin C (mg)	71 (32)	70 (28)	70 (28)	− 0.2 (− 27.3 to 11.1)	− 0.2 (− 27.3 to 11.1)	3	3

*Significantly different from original ($P < 0.05$; Wilcoxon signed-rank test).
[1]Both unambiguous errors and ambiguities corrected: comparisons made are with the original, uncorrected data.
[2]Except for one case, all changes were to an adjacent third.
[3]One individual (3% of sample) changed from the highest to the lowest third in fat intake after ambiguities had been corrected.

errors than manual coding (Feskanich *et al.*, 1988; Sheppard *et al.*, 1990). The mean of 3.8 (SD 3.3) errors per record in the present study was lower than the 5.9 (SD 5.6) per record found by Sheppard *et al.* (1990) for their direct entry coding method, both of these being lower than the 8.6 (SD 6.5) per record for the present manually coded subsample and the 9.7 (SD 7.9) per record found by Sheppard *et al.* (1990) for manual coding. These authors did not discuss ambiguities, presumably because they used weighed records; it is assumed that their error rates would be equivalent to our results with ambiguities excluded.

Consistency among coders and over time in assigning portions can be difficult to achieve in manual coding (Feskanich *et al.*, 1988). Within-survey inconsistency, or lack of precision, is easier to prevent with good database management practices on a computerized coding system than with a manual system where each coder has a separate copy, easily altered, of the source list of codes and portion weights. However, new kinds of error can occur. Because the DIDO program stores in memory and displays the last portion size selected upon reselection of the same food, the same portion size may be coded for a subject who had repeatedly eaten the same quantity of a food item (e.g. two teaspoons of honey on toast each morning for breakfast), merely by pressing the <enter> key. This useful time-saving feature could also lead to perpetuation of portion sizes chosen inaccurately the first time, and thus to the occurrence of multiple errors.

Ambiguous records

Inappropriate interpretation of ambiguous records by a less-experienced coder can lead to much-increased error rates. There were many more ambiguity 'errors' in the 1989 than in the 1982 subsample (Table 1); the error rate was doubled in 1989 when ambiguities were included. This was partly due to the numerous replicates of some of the 1989 ambiguities, and partly because of the memory-effect of DIDO.

No coding method can be guaranteed to overcome such problems of interpretation where it is known or suspected that the survey member has given an inadequate record of all that was eaten. It would appear superficially that a weighed record would be much less prone to this problem, since the subject is supposed to weigh everything and therefore if there is no entry for margarine on bread, for instance, it was not eaten. However, this assumption is not necessarily true and it may be that weighed records are taken to be more indisputable than is justified, and that the apparent scientific exactitude of having a weight for each entry affords spurious confidence in the method. In frequency-questionnaire methods the interpretation issues are 'resolved' by the subject, and diet histories rely on a combination of the subject's own assessment of habitual diet and the interpretation of the interviewer.

Ambiguities could be resolved in most cases by later referral to the subjects, but resources do not often permit this in large surveys such as this one. The 2-day recall used in this study as part of the 7-day record was useful in the resolution of ambiguities. The recording of the subject's diet by a trained observer gave some clues on missing details omitted by the subject, and the different handwriting also helped to solve some problems. The inclusion in the diary of a brief questionnaire asking about some often-used foods (e.g. bread, spreads and milk and sugar in beverages) would also have helped in resolving coding ambiguities. Such questions have already been added to the diary in adaptations for use in other large surveys.

This error analysis exercise has demonstrated the importance of establishing a coding policy for each dietary survey, which should be documented for reference by the coders during coding and by the investigators during data analysis and interpretation. Consistency of coding policy, both over time and among coders working on a large survey, is as important as the calibration of weighing scales for weighed intake studies.

Conclusion

One of the advantages of the DIDO-coding system brought to light by the present exercise is the ease with which coded records could be accessed and checked against the original diary. This is a supremely tedious task to attempt with the manual method—in fact, so tedious that thorough checking of large numbers of records is often impractical. This important fact, together with the improved speed and accuracy observed, demonstrates that direct data entry and computer handling offers considerable advantages over manual data processing, especially for studies of this size.

Acknowledgments

We are indebted to the survey members for completing the diet diaries, to the survey nurses for data collection and to the coders, A. Ahmed, L. Barron, J. Boxall, C. Brace, L. Cooke, H. Godfrey, S. Levitt, E. Procter and P. Rayner. We thank M. Thorogood for the use of the food photographs, W. Hilder for assistance with data management and F. Braddon for helpful comments on the manuscript.

References

Black, A.E. (1982) The logistics of dietary surveys. *Hum. Nutr.: Appl. Nutr.* **36A,** 85–94.

Braddon, F.E.M., Wadsworth, M.E.J., Davies, J.M.C. & Cripps, H.A. (1988) Social and regional differences in food and alcohol consumption and their measurement in a national birth cohort. *J. Epid. Comm. Health* **42,** 341–349.

Crawley, H. (1988) *Food Portion Sizes.* London: HMSO.

Edington, J., Thorogood, M., Geekie, M., Ball, M. & Mann, J. (1989) Assessment of nutritional intake using dietary records with estimated weights. *J. Hum. Nutr. Dietet.* **2,** 407–414.

Feskanich, D., Buzzard, I.M., Welch, B.T., Asp, E.H., Dieleman, L.S., Chong, K.R. & Bartsch, G.E. (1988) Comparison of a computerized and a manual method of food coding for nutrient intake studies. *J. Am. Dietet. Assoc.* **88,** 1263–1267.

Holland, B., Unwin, I.D. & Buss, D.H. (1988) Cereals and Cereal Products: Third Supplement. *McCance and Widdowson's The Composition of Foods* (4th edn). Nottingham: Royal Society of Chemistry.

Holland, B., Unwin, I.D. & Buss, D.H. (1989) Milk and Milk Products: Fourth Supplement. *McCance and Widdowson's The Composition of Foods* (4th edn). Cambridge: Royal Society of Chemistry.

Nelson, M. (1983) A dietary survey method for measuring family food purchases and individual nutrient intakes concurrently, and its use in dietary surveillance. PhD thesis, University of London.

Paul, A.A. & Southgate, D.A.T. (1978) *McCance and Widdowson's The Composition of Foods.* (4th edn). London: HMSO.

Sheppard, A.M., Coles, K.J., Fehily, A.M. & Holliday, R.M. (1990) A direct data entry system for processing dietary records: comparison with manual coding. *J. Hum. Nutr. Dietet.* **3,** 209–214.

Wadsworth, M.E.J. (1991) *The Imprint of Time.* Oxford: Clarendon Press.

Wadsworth, M.E.J., Mann, S.L., Rodgers, B., Kuh, D.J.L., Hilder, W.S. & Yusuf, E.J. (1992) Loss and representativeness in a 43 year follow up of a national birth cohort. *J. Epid Comm. Health* **46,** 300–304.

Wiles, S.J., Nettleton, P.A., Black, A.E. & Paul, A.A. (1980) The nutrient composition of some cooked dishes eaten in Britain: a supplementary food composition table. *J. Hum. Nutr.* **34,** 189–223.

MS accepted September 1995