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SAMPLING FOR HOUSEHOLD SURVEYS

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SAMPLING FOR HOUSEHOLD SURVEYS

1. INTRODUCTION

1.1 Types of household survey

This paper covers surveys of household budgets, consumption and nutrition. Budgets cover income, expenditure and household enterprises. Consumption surveys generally cover all the ground covered by budget surveys, plus consumption of home produce and other non-monetary transactions. Nutrition surveys, in that they attempt to measure food consumption, are in principle included in the programme of consumption surveys, but the term is usually applied only where particular attention is given to the weighing of food - in some cases even after cooking. Moreover, nutrition surveys attempt to measure actual consumption on each day of the survey, while in many consumption surveys consumption is estimated as far as possible from transactions, and failing this from changes in stocks.[1]

None of these terms is used in a standardized way. Moreover the term "household survey" does not have any accepted definition; it is adopted in this paper solely for convenience, to cover the whole constellation of different types of surveys mentioned above. A "household survey" may include any or all of these operations.[2]

Besides varying in the broad subject-matter of the data collected, household surveys vary widely in objectives. The simplest type of survey is limited to the estimation of total household expenditure on different items, in many cases for a strictly limited population, for the purpose of

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1/ In French, distinction is sometimes made between the "enquête alimentaire" and the "enquête nutritionelle", the former dealing with food consumption in general, the latter with its distribution in relation to needs.

2/ At the meeting of the ECA Working Group of Consultants in Household Surveys in 1961 (see Section 1.4 below), the term "household survey" was taken to include any survey for which the sampling unit is arrived at through the household. This could include demographic, agricultural and various other surveys excluded from the present paper.

Demand analysis may be performed on a household or on a per capita basis: different bases may even be used in the same survey depending on the product whose demand is analysed. Here again, the precise definition of the household is not likely to affect directly any conclusions drawn, even where the analysis is based on households.

Distribution of income is generally given for households, but can be easily converted to an individual basis where wage income alone is involved.

It will be seen from the above that in many cases the definition of the household for reporting purposes is not of crucial importance.

Its definition for operational purposes is always important, but here there is no need for consistency between different areas or different countries. Local rules can be made in the light of the particular local situation, with the aim of giving field workers the clearest possible instructions.

In broad terms, the following definitions seem to be generally accepted:

The budget group is a group of persons whose income is pooled and whose expenditure is subject to the decision of one person.

The food consumption group is a group whose meals are prepared in common.

In practical applications such definitions are hardly precise enough to be fully operational and have to be supplemented by local rules.

In some regions the budget and food consumption units are the same, but in many rural areas they are distinct, the former being closer to the idea of a household, the latter representing a group of households who eat their meals together. Clearly this causes difficulties when it is desired to collect data on both topics by the same operation. This problem is treated in Section 2.4.5.

Except where it is essential to distinguish the different types of unit we shall use the term "household" in this paper, for the sake of simplicity.

1.4 References

Most survey reports contain a description of the methods used, but there appear to be only two published references in which the methodology of household surveys in general is discussed in application to Africa. These are the following:

CCTA (now OAU-STRC) (1964). Méthodologie des enquêtes sur les budgets familiaux (6 vols.), London and Paris. See in particular Vol. VI: Synthèse Générale, by J. Causse and L. Marciniak.

Winter, G (1967). Méthodologie des enquêtes "Niveau de vie" en milieu rural Africain. ORSTOM, Paris.

The latter publication has been of particular value in preparing the present paper.

Two African meetings on household survey methodology have been held, whose reports have been consulted:

ECA Working Group of Consultants in Household Surveys, Addis Ababa, 11-20 December 1961. (Report No. E/CN.14/130).

ECA/FAO African Technical Meeting on Food Consumption Surveys, Rabat, 17-25 July 1963.

ABBREVIATIONS

P.S.U.	Primary sampling unit, i.e. first-stage unit.
S.S.U.	Secondary sampling unit, i.e. second-stage unit.
P.P.S. sampling	Sampling with probability proportional to size.
E.A.	Census Enumeration Area.

2. RURAL HOUSEHOLD SURVEYS

2.1 Sampling units and sampling frames

It can be taken for granted that any rural household survey will be based on a sample of two or more stages. The 1st stage will involve sampling of area units and the last stage of households, and there may or may not be intervening sampling stages.

Rigorous sampling requires a list of units from which to select the sample, or a sampling frame. In the two following sections we examine the availability of such sampling frames for area units and for households.

2.1.1 Area units

In most African countries, sampling frames are available for small area units from the most recent census, each unit being listed with its census population. Such units are generally of less than 500 population in French-speaking countries, but larger - in some cases much larger - in most English-speaking countries and UAR. The detailed position is described in Section 3.1.1 of the paper for this seminar, Sampling for Demographic and Housing Surveys and Civil Registration[1].

It will be seen in later sections that in most cases - depending on the frequency of visits and number of households covered per enumerator - it is desirable to have the enumerator working only within one locality on any given day. The area units mentioned above, however, often cover more than one locality (by "locality" is meant village or hamlet). A further grouping of the sample may therefore be necessary within census area units, and in some cases this may be achieved by delimiting smaller area units within selected census area units. Such secondary area units in general have to be created by a field operation: though the list of census localities may help in this, it does not generally allow well defined secondary area units to be constituted withoug a field visit.

1/ E/CN.14/SM/3.

2.1.2 Households

The working unit, or unit of enquiry, is the budget group or food consumption group. No list of such groups exists for any rural area in Africa. Even where these groups approximate to households in the demographic sense, appropriate lists are very rarely available since the mobility of the population makes them go rapidly out of date.[1/]

It may be assumed, therefore, that for almost any rural household survey in Africa it will be necessary to make a list of budget or food consumption groups from which to select the survey sample, within each selected area unit.

2.1.3 Stability of the household as a sampling unit

It will be seen in Section 2.2 that in many household surveys each budget group in the sample is surveyed over a long period - typically one year. During this time the composition of the group may change. This may occur through movements of the population (births, deaths, migration), or through regrouping of units following marriage, etc. In at least one survey there has been a suspicion that individuals have left a sample group to escape the survey. There are also short-term movements of persons - visits to other households, other villages, or places outside the domain of the survey. Finally, the composition of the group may be changed as a result of the recognition by the enumerator of an error in delimiting the group in the first place.

A similar problem arises from changes in composition of the group between the time of making up the sampling frame and the time when the selected groups are surveyed. Since the former operation is necessarily superficial, some adjustments due to recognition of error are likely,

Changes in the unit which are random will not appreciably distort the results of the survey. However, some of the sources of change mentioned above are likely to have systematic effects. The most important are perhaps the following: error in delimiting the units at the time of

1/ Again, the position is described in more detail in the paper mentioned above, E/CN.14/SM/3.

drawing up the sampling frame, bias in deciding which part of a group to follow when the group splits, failure to take account of temporary absences of members of sample groups, and double counting of transactions of persons whose status as residents or visitors is uncertain.[1]

These errors have a direct effect on the main survey results. If the number of person-days covered by the interviews is x% less than the number assumed in reducing the survey data to per capita form, then any per capita estimates quoted will be x% underestimated. If the units actually interviewed are, on the average, y% smaller in size than the average unit in the sampling frame, and if there has been no net change in the total size of the population under study, then any raised estimate from the survey will be y% underestimated.

The best safeguard against serious bias from such sources is to keep a running record of the number of persons covered by each day's enquiry in each household. Results expressed in per capita form should then be derived through the number of person-days of observation. If raised results are required (total expenditure of the household sector, etc.), the number of individuals in the sampling frame should be determined at the time of drawing up the frame. This is to be compared with the average number of persons covered per day in the interviews. The ratio of these two quantities should be adopted as the raising factor.[2]

In many surveys these adjustments have not been made and there has been no attempt to deal with bias resulting from instability of the household as a sampling unit.

1/ "Double counting" may be read, more strictly, as "double probability". A person who is counted in a sample household may also have some link with another household. If his status in the second household is such that he would have been counted in it had that household been selected, then he has had a double probability of selection, with consequent biasing of the results.

2/ These adjustments should prevent any gross bias, though they still do not fully correct for such biases as the over-weighting of individuals who appear in more than one household. But this will now be a second order effect, in the sense that it will introduce bias only in so far as such persons are systematically different from the average.

2.2 Time sampling

By "time sampling", or "sampling in time", is meant the selection of a sample of time periods to represent the whole period with which the survey is concerned. For example, if a household is interviewed every day for a month, then this month is a unit in the time sample. Discussion of the topic of time sampling involves all questions relating to time relationships within the sample design. In the present section we discuss successively:

2.2.1 Total period of the survey

2.2.2 Period of continuous recording in each household

2.2.3 Frequency of interview and time reference of the interview

2.2.4 Rotation versus renewal of the sample; return visits after an interval; retrospective questioning.

2.2.1 Total period of the survey

Most rural household surveys have covered a period of one year. Any shorter period would not allow seasonal variation to be taken into account. (For most purposes it is desired to eliminate seasonal variation; occasionally it is desired to estimate it. In either case a full year of observation is required.) On the other hand, a period longer than one year is often difficult to handle administratively and leads to excessive delay in publication of results.

Some countries have adopted a procedure of covering one region at a time in a succession of almost independent annual surveys. The current survey in Lesotho provides an example: the country has been divided into 3 regions, each of which is being surveyed for one year, but with a 6-month overlap so that the total survey period will be 2 years. In Cameroon a less tightly organized schedule was used: four surveys were carried out over the period 1961-65, three being rural surveys undertaken in succession and one an urban survey (Yaoundé) approximately coincident in time with the last of the rural surveys. In Ivory Coast, half of the country was covered in one year, the other half in the following year.

If survey results are to be of value it must be supposed that they remain at least approximately valid over a period longer than that of the survey. In other words, the survey period must be regarded as a sample representing a longer period. The question of whether this sample is in fact likely to be approximately representative should always be considered. In some countries, notably those of low rainfall, the rural economy undergoes very wide fluctuations depending on the year's rainfall. In such cases a single year cannot reasonably be expected to represent every year. This problem should be considered before launching the survey, and the question should be asked whether to extend the survey period to cover two or more years, or whether on the contrary the cost of undertaking the survey may be unjustifiable.

2.2.2 Period of continuous recording in one household

In all household surveys, the period in respect of which the principal data have been collected at each interview - the time reference of the interview - has been the same as the time between interviews, so that the interviews cover a continuous recording period in each household. This arrangement makes for more accurate data collection, for two reasons. Firstly, reports of transactions can be checked against the situation at the beginning and end of the period (the check can be applied to money or goods - that is, against cash balances or against stocks). Secondly, the enumerator asks for a report of transactions "since my last visit"; this fixes the reference period more clearly in the mind of the respondent.

The length of the period of continuous recording is, of course, independent of the frequency of visits (discussed in Section 2.2.3 below). Thus, one could interview a household every day for a month, or only once a week for a month. As long as the questions at each interview cover the period since the preceding interview, then the whole month is covered, and this is the "period of continuous recording".

In Ivory Coast a subsample of the households in the survey were interviewed every day for a year. In a few countries, daily interviews

have continued for only one week in each household. But these are extreme cases. In the majority of rural African household surveys the period of continuous recording has been one month for budgets and one week, or slightly less, for nutrition.

The period of one month for budgets has been chosen partly because of the periodicity of wage payments (even when the sample household is not wage-earning, the presence of wage-earners in a village may affect the economy of non-wage-earning households). A period of one week would only cover one market-day (in most regions) and the random fluctuation affecting the recorded purchases would be large; moreover there is an impression that over a short period a household's behaviour might be substantially modified by the presence of the enumerator, but that this distortion could hardly continue over a period as long as a month.[1/] A period longer than one month is usually considered unacceptable to the household under study. In addition, it must be noted that when the frequency of visits is daily, then throughout any one period of continuous budget recording in a given group of households the number of villages in the sample cannot be greater than the number of enumerators. Thus the total sample size of 1st stage sample units becomes severely limited if the period is extended too much.

The period of one week for nutrition has generally been chosen because food consumption in rural areas is found not to vary very much from day to day, so that a period longer than one week would give little additional information. Moreover, as will be seen in Section 2.2.3, a nutrition survey generally requires at least two visits daily to the household by the enumerator and clearly this imposes considerable demands on the housewife. It is natural therefore to wish to reduce to a minimum the number of days spent with each household. In many surveys the households surveyed for one week for nutrition are a subsample

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1/ It would be easy to collect evidence on this, by comparing expenditures in the first week of the survey for each household with those in later weeks, but this has never been done for any rural survey.

(rotated each week) of those surveyed for one month for budgets (see Section 2.2.4). This may reduce the disturbing effect of the presence of the enumerator on behaviour recorded in the nutrition survey, since the household is in most cases habituated to the enumerator's budget visits by the time nutrition recording begins.

In many household budget surveys an attempt is made to extend the period of continuous recording to a much longer period than one month by occasional return visits, at which only summary data are collected. This is considered in Section 2.2.4 below.

2.2.3 Frequency of interview and time reference of the interview

In most African budget surveys, and in all African nutrition surveys, the households have been interviewed at least once every day during the period of continuous recording.

For budget surveys, however, less frequent visits have not been uncommon. In the three rural surveys in Cameroon, budget recording visits were made every second day, in Madagascar (1968) every third day, and in Lesotho once a week. In the two former surveys, food consumption was estimated from a subsample visited daily, but in Lesotho even food is being recorded only on a weekly basis, there being no daily visits whatever.

As we have seen in Section 2.2.2, the frequency of interview in household surveys in Africa has always been the same as the interview reference period. Thus, frequency of interview should depend on the accuracy of respondents' memory. If respondents can reliably report their behaviour over a memory period of 1 week, then interviews can be organized on a once-weekly basis.

This is a question on which much more research is needed. In two surveys in Ghana[1/] in which both daily and weekly recording were used,

1/ Central Bureau of Statistics, Field Survey Work in the Ghana Statistics Office, Statistical and Economic Papers, No.8, Accra, 1961.

it was found that the weekly record of total expenditure fell below the daily by 17% in one survey and 22% in the other. There was some evidence to suggest that the difference was mainly due to the more irregularly purchased items. More recently, an experimental survey has been carried out by the University of Ghana (Institute of Statistics) to compare results from recall periods of 1 day, 2 days, 3 days and 7 days. Frequency of purchase of 10 commonly purchased items was analysed. For all 10 items taken together, the weekly period showed a deficiency of 16% compared with the daily period. For the 3-day period, the deficiency was 9%.[1/] The former figure agrees well enough with the earlier Ghana surveys, but a disturbing feature of the findings was a very large difference in the memory effect for different items. For bread, for example, the 7-day deficiency was 70%; for firewood, 44%; for cassava and garden egg, approximately zero. There was again a definite tendency for the less frequently purchased items to show a larger error, though there were some exceptions (the very frequently purchased kenkey showed a 41% deficiency).

These experiments relate to comparatively well-off populations - urban in the case of the University of Ghana study. In poorer rural areas, where purchases are rarely made more than once a week, it seems reasonable to suppose that recall periods somewhat longer than one day should give acceptable results, at least for budgets, if not for consumption. The magnitude of the errors observed in the experiments quoted must, however, induce caution. They clearly indicate the urgent need for some purely methodological research in this field.[2/]

In nutrition surveys the situation is different because the enumerator is required to weigh the foods cooked, and this can only be done if he is present while the meals are being prepared. It follows that he must

1/ Percentages computed from difference between the daily averages for 1-day and 7-day (or 1-day and 3-day) periods, divided by the daily average for all periods pooled. All differences reported in this section were significant at the 95% confidence level or higher.

2/ For further references to such research, see page 17, footnote 1.

make 2, or even 3, visits to the sample household each day. As with budget enquiries, it is always arranged for the sample days to run consecutively for any one household. This simplifies the problem of recording left-overs (food cooked one day and consumed the next) and reduces the danger of the household putting on a special show for the enumeration day. Thus we find in the typical African rural nutrition survey that the enumerator visits the same household 2 or 3 times per day, every day for 5 - 7 days.

2.2.4 Rotation versus renewal of the sample; return visits after an interval; retrospective questioning

In many surveys the "period of continuous recording" referred to in Section 2.2.2 does not represent the whole of a household's contribution to the survey data; generally, arrangements are made to keep in touch with each sample household over a much longer period. This may involve relatively infrequent return visits at which data are collected in broader categories or for certain classes of transaction only; in such cases the time reference adopted is generally the period since the last visit, for exactly the same reasons as those set out at the beginning of Section 2.2.2. Or there may be a further "period of continuous recording" for each household, after an interval of a few months. Quite often, both procedures are used: over the year of the survey there are two or three periods of continuous recording for each household, and the interviewing periods are covered by retrospective questioning. Where this arrangement is adopted, there may either be short visits for retrospective questioning between the periods of continuous recording, or the whole interval between periods may be covered by one retrospective questionnaire used at the start of the second (third, etc.) period.

While complete renewal of the sample every month increases the total sample size, and hence the precision of estimates of annual totals, there are several reasons for preferring partial renewal arrangements such as those described above. Firstly, by following each household

over a year a much more precise estimate can be made of seasonal variation. Secondly, the annual income of each sample household can be obtained, and hence the income distribution and the relation of income to other variables. With complete sample renewal every month, annual income can be estimated as a total or average, but its distribution between households cannot be obtained and it cannot be cross-tabulated against other characteristics. The same reasoning applies not only to income but to savings, investment, consumption, etc. Thirdly, certain items are so rarely purchased that the sample of purchases recorded in the continuous recording periods is likely to be too small to give reliable data. By extending the recording period with retrospective questions for these particular items, the sample can be greatly increased. This procedure has been used particularly for collection of data on purchase of clothing and durables.

The exact arrangements used for extending the recording period have varied widely in different surveys.

The simplest arrangement is that being used currently in Lesotho. Here four visits per month are made to every household in the sample. That is, instead of frequent visits over a short period supplemented by infrequent visits covering longer periods, visits of intermediate frequency are made over the whole period.

At the other extreme but almost equally simple is the arrangement adopted in Ivory Coast,[1] where a small sample was interviewed every day for a year, the remainder of the sample being covered for one month per household with complete renewal every month.

In the Ghana rural surveys of the late 1950s,[2] all households were visited weekly for the whole period of the survey, and at these visits budget information was collected in broad categories. At the same time a subsample, changed each month, was visited on a daily basis for one

1/ CCTA, op. cit., Vol. IV.

2/ Ghana Central Bureau of Statistics, op. cit.

month, detailed information being collected on domestic expenditure and consumption and on sales of farm produce (other than cocoa). In addition, retrospective questions on purchase of clothing and durable goods were asked covering the 12 months prior to the survey.

In the rural surveys in Cameroon the procedures used varied, but the methodological report[1] based on the surveys recommends, for each sample household, three periods of continuous recording in the year, each of four weeks duration and separated by 3 months, with monthly visits for retrospective questioning during the intervals. Almost the same design is being applied in the current rural surveys in Madagascar.

All of these arrangements raise the question of the reliability of retrospective questionnaires. Evidence has already been cited (Section 2.2.3) which indicates that even the 1-week reference period leads to very substantial under-reporting. At first sight this may suggest that methods which depend on 1-month or 2-month periods cannot be justified. In fact, however, this must depend on the use that is made of such recall data. Where the purpose is to estimate seasonal variation, to obtain the distribution between households of annual totals such as income, investment, etc., or to classify households by annual income for cross-tabulation with other variables, even very inaccurate data may be useful. All that is necessary is that the data should properly reflect

1/ Winter, G., op. cit.

the changes over time: absolute levels can then be put in from the daily records.[1/]

On the other hand, where retrospective questionnaires are used to obtain a more reliable sample of transactions of a rare kind, such as purchase of clothing and durables, any error will directly affect the estimates obtained. In this case there must be serious doubt whether the use of retrospective questioning is justified. In many surveys retrospective questioning has been used for this purpose to cover a period prior to the survey -- i.e. a period not defined as falling between two of the enumerator's visits. Such open period questions are even less reliable.

For all applications of the retrospective method whose purpose is direct estimation of absolute quantities, a reasonably cautious policy would be to limit the method to periods bounded by two visits of an enumerator, to obtain inventories at the two visits, and to check the response to the retrospective questions against the change in the inventories. If the inventory made at the first visit is not available to the enumerator at the second visit, such a check should give an indication of the level of accuracy. A further visit may then be made

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1/ There is, nevertheless, some slight indication that retrospective data may not be reliable enough even for this modest application. Thus the large irregularities found in the University of Ghana experiment remain unexplained; it may well be that they are due to some factor which would be irregular over time, so that seasonal and other time changes would be distorted. One of the most thorough experiments on recall error in household surveys was carried out by the US Bureau of the census. It was found that the error increased from the 2nd to the 3rd of 3 monthly interviews, suggesting that repeated interviewing may lead to increasing error ("conditioning effect"). If this applied to African rural surveys the attempt to use retrospective methods for the purposes mentioned above would be vitiated. The need for specifically African research in this area is evident.

The report on this US research includes a useful bibliography of research reports on response errors in household surveys and related topics. US Department of Commerce, Bureau of the Census, Response Errors in Collection of Expenditures Data by Household Interviews: An Experimental Study, Technical Paper No. 11, Washington DC, 1965.

to reconcile any discrepancy and obtain the best possible estimate of the facts. The method is subject to some obvious limitations; for example, small items may be purchased and consumed wholly within the period, and some items, such as services, cannot in principle be inventoried.

Before leaving the topic of response error, we should emphasize the importance of subjecting household survey data to all possible cross-checks, both internal and external. In most surveys the possibilities of checking are numerous, but this topic lies outside the scope of the present paper. At the same time, the evidence cited above showing that the error may vary widely from one item of purchase to another must lead to caution in interpreting the results of such checks. Because a few items check well it cannot be taken for granted that all the survey results are accurate.

2.3 Stratification

Stratification may be applied at the geographical stage of sampling or at the household stage. The purposes are generally different and the two cases will be treated separately.

2.3.1 Geographical stratification

Characteristics of households and their consumption vary considerably between different types of region (mountain, savanna, forest, coast, etc.) and between different ethnic groups. To ensure proper representation of all regions and groups it is advisable to stratify the population on the basis of such characteristics and to carry out the area-sampling separately in each stratum. Generally the same sampling fraction will be used in all strata, the purpose of stratification being simply to ensure that this fraction is actually attained within each stratum.

2.3.2 Stratification of households

In most areas individual households vary widely in their level of living. A proportionate sample, i.e. one with a constant sampling fraction for all households, will be optimal if the purpose of the survey is to

give a general picture of the way of life of the population. Such a sample design has been adopted for many rural household surveys in Africa (e.g. Cameroon, Ghana (1962), Madagascar (1968), Morocco, Nigeria).

For most other purposes, however, a proportionate sample is relatively inefficient, because the wealthier classes of the population contribute, per household, a disproportionately large amount of the information sought by the survey. Thus, if the purpose is to estimate total income or expenditure of the household sector of the economy, optimal sampling efficiency requires that greater weight be given in the sample to the wealthier households. The same applies to estimation of household production, savings and investment and to analysis of the relation between household income on the one hand and expenditure on particular items on the other ("demand analysis"). All of these are common objectives of household surveys, and all require that a higher sampling fraction be used in sampling wealthier households if sampling error is to be minimized.[1/]

Unequal sampling fractions, varying with income, can only be applied if each household's income can be estimated before household sampling begins. The usual procedure is to obtain such estimates in the course of the listing operation designed to create a sampling frame of households in each selected PSU.[2/] Very rough estimates of income are adequate for the purpose of increasing the efficiency of the sample, and errors in such estimates will not result in bias but only in a slightly smaller gain in efficiency.

A common method of estimating income is to ask for a statement of sales of produce or livestock during the preceding year. Alternatives are to have the households classified by the village chief, to classify

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1/ The use of unequal sampling fractions involves a biased sample, but not biased results, since the bias is corrected at the estimation stage by weighting.

2/ PSU: Primary sampling unit, i.e. first-stage unit.

by some visible feature such as a metal roof to the dwelling, or (as in Ivory Coast) to distinguish households whose head is head of an extended family. Other solutions will occur to the statistician who has special local knowledge. Whatever method is adopted, the households in the selected PSU are classified into a small number of strata (typically 2 or 3) and sampling fractions are adopted which are higher for the wealthier strata. The optimal choice of sampling fractions depends in principle on the survey objectives and on the variances within strata. In practice, there are nearly always several simultaneous survey objectives, each of which would give rise to a different optimum, and the variances are almost completely unknown. In these circumstances one can do no better than follow certain rules of thumb. The following are suggested:

(i) Sampling fractions should be chosen so that the number of households selected in each stratum will be very roughly the same. However, this rule should be subject to the remaining rules listed below being satisfied.

(ii) No two stratum sampling fractions should differ by more than a factor of about 8 to 1. The use of very widely differing sampling fractions is almost certain to mean a large departure from optimal efficiency for some variable other than the one in terms of which the stratification is supposed to be optimal. If the variation of sampling fractions is kept within limits, the design may not be optimal for one chosen variable, but we can be fairly sure that it will not be too far from optimal for a large number of other variables.

(iii) Contrariwise, no two strata sampling fractions should be too close - perhaps no closer than a factor of 2 to 1 would be a reasonable rule. The gain in sampling efficiency by using unequal sampling fractions will not be worth the added complexity if two strata are distinguished for which the sampling fractions are not very different.

(iv) No more than 3 income strata should generally be created. The information available for defining such strata is scanty and unreliable in nearly all rural African surveys. For this reason it will rarely be worth creating more than a very small number of income strata.

Stratification with unequal sampling fractions has also been used in several surveys, including nutrition surveys, to ensure an adequate sample of certain relatively rare classes of household, such as non-farming households, traders, wage-earners, etc. Unless a higher sampling fraction is introduced for such groups, their representation in the sample will be very small and it will not be possible to reach reliable conclusions about their behaviour. Sometimes, as in Lesotho and in the Kenya Central Province survey, it may be decided to omit non-farming households entirely. This is appropriate where the main concern of the survey is the conditions of primary production.

An important factor determining budgetary and nutritional levels is the size of a household. This can be easily determined during the listing operation. Stratification by size of household, with a constant sampling fraction, would contribute to sampling efficiency by ensuring that the sample covered all sizes with almost exactly the chosen probability. However, the same aim can be achieved more easily by systematic sampling and this should always be used. The procedure is as follows. The size of each household is recorded during the household listing operation. Any income or occupational stratification which may be desired is first carried out. Then, within each stratum the households are listed in order of size and a systematic sample[1] is selected from the list in each stratum.

1/ I.e. a sample taken at fixed intervals from a random start. The "random" start for any stratum should preferably be varied systematically from 1 PSU to another - e.g. 1 in the 1st PSU, 2 in the 2nd, etc., but with a different pattern in each household stratum.

2.4 Sample design

The sample design for a household survey has to meet a number of requirements of which the most important are the following:

i) Time samping requirements. These have been discussed in detail in Section 2.2.

ii) Stratification requirements. Discussed in detail in Section 2.3.

iii) Grouping in space. The household sample must be grouped so that for a given enumerator at a given time his sample households are within a short distance of one another.

iv) Self-weighting sample. Most household surveys involve a large number of data variables. It is an advantage if the sample can be designed to be self-weighting so that results taken from the sample, expressed in percentage or per capita form, can be quoted as directly applicable to the population without the need for weighting. If this cannot be achieved it remains desirable to limit the number of different weights to the smallest possible, for example by use of a design that is self-weighting within strata.

v) Possible integration of nutrition survey with other objectives. This affects the time sampling requirements and raises a problem of possible discrepancy between the two units of enquiry: the budget group and the food consumption group.

vi) Sampling efficiency and cost. When the above conditions have been met, it is desirable to choose that sample design which will give minimum sampling error for given cost.

The implications of these requirements for sample design will now be examined under each of the above headings in turn.

2.4.1 Time sampling requirements

Experience in Africa shows that a single enumerator can manage about 4 or 5 visits to households per day for budget recording. Nutrition recording cannot be performed efficiently for more than one household per day, but an enumerator covering one household for nutrition can reasonably be expected to visit 2 or 3 others for budgets. These figures assume that all the households covered by one enumerator on any one day are in the same village (see Section 2.4.3 below).

In nearly all African budget and nutrition surveys, as we have seen, households are visited every 1, 2 or 3 days throughout the period of continuous recording. Clearly this implies that throughout this period the enumerator will stay within a limited area, normally a village or census enumeration area (EA), visiting each sample household at the required time-intervals. For example, if a 2-day memory period is considered appropriate, he will visit half of the sample households one day and half the next, repeating this until the end of the period in the village concerned. If a nutrition survey is combined with a budget enquiry, the period of continuous recording being 1 week for the former and 4 weeks for the latter, then a sample of 4 food consumption groups is selected in the area and the enumerator makes daily visits to 1 of these each week.[1/] At the same time he visits a sample of budget groups for budget recording - half of the sample every 2nd day, or one-third every 3rd day, according to the memory period considered appropriate, continuing thus for 4 weeks.

1/ Often the period for nutrition recording is reduced to 5 or 6 days in order to give the enumerator a day or two's rest.

At the end of the complete period of continuous recording (i.e. after 4 weeks in the above example), he moves to another sample village, where he repeats the same routine.

If return visits are required with repeat periods of continuous recording, he continues moving periodically from village to village until the time comes for him to return to the starting village. If brief return visits for retrospective questioning are scheduled, these may be performed either by the supervisor, or by a special reserve enumerator, or by the regular enumerator during the brief interim when he is due to transfer from one sample village to the next.

It will be clear from these arrangements that once the time-sampling parameters have been chosen, this fixes the number of households to be selected in each village (with a minor reservation to be noted below). It also fixes the number of villages per enumerator and hence the total sample size per enumerator. Thus, once the number of enumerators is decided, all the main parameters of the sample design have now been determined.

It is also clear that it will be a convenience in organizing field work if the number of households selected in each village and allocated to one enumerator can be kept exactly, and not merely approximately, to the number decided in advance. In the case of a nutrition survey this condition is almost a necessity: in the example given above, we need exactly 4 food consumption groups per enumerator in each village. 3 would leave the enumerator underemployed for a week and 5 would be impossible to handle. For the budget survey it is possible to be a little less strict: it does not matter too much if the enumerator has one more or one less household to visit on some days.

One further time-sampling requirement should be mentioned. There is some danger that the monthly movements of enumerators from village to village might produce systematic changes in the observations which

could be misinterpreted as seasonal changes. This can be avoided by making sure that the different enumerators do not all move according to the same plan. For example, they should not all move together from north to south, nor should they all start work in the most accessible village of their sample and move on to the less accessible. Ideally, each month's sample should be representative of the whole domain of the survey. A practical procedure might be to work out the enumerator's itinerary as a circular tour and then to fix the starting point in that itinerary by random selection independently for each enumerator.

2.4.2 Stratification requirements

Stratification at the area-sampling stage presents no special problem.

Stratification at the household-sampling stage with unequal sampling fractions present a problem in relation to the self-weighting requirement and this is discussed in Section 2.4.4 below.

Household stratification requires that information be collected at the household listing stage in each selected PSU to enable households to be allocated to the appropriate strata. However, there is no logical necessity to collect this information for all households in the PSU - it could be collected for a random sample only, provided the sampling fraction at this stage is at least as large as any that it is intended to apply in the selection within strata. An example may clarify this.

Suppose we have decided on stratification by estimated income, using strata sampling fractions 1/2, 1/6 and 1/10. We could list all the households in the PSU, collecting income estimates for each household, stratify the households and select in each stratum with the fractions mentioned. But alternatively we could, when listing households, collect income estimates only for every 2nd household.[1/]

1/ As households may not be immediately identifiable, one might prefer the method of selecting every household in every 2nd house.

We would then stratify this sample of households and select in the strata with fractions 1/1, 1/3 and 1/5. The result is the same and we have saved much work at the listing stage.

There are two reasons why this procedure is not commonly used.

i) If an intermediate sampling operation is to be inserted, so that the final household sample is not selected from all households in the PSU, then it is normally preferable to make this additional operation an area-sampling stage. That is, the PSU is divided into smaller areas, one (or more) of which is selected. This has the advantage of grouping the interview sample into a smaller area, an important requirement which is discussed in Section 2.4.3 below.

ii) The listing stage is often combined with a demographic survey and in many cases for the purpose of this survey it is desired to interview every household in the selected PSU. In this case there is very little extra effort in collecting stratifying information from every household.

Nevertheless, if population density is high and if the units available as PSUs are small, so that the interview sample is already sufficiently concentrated, and if there is no conflict with the requirements of an associated survey, the procedure of sampling houses or households before stratification would generally be well worth applying. A further important condition should, however, be mentioned. To allow the enumerator to select a sample without pre-listing offers him a serious temptation to manipulate the listing in such a way as to select the more easily handled households. Either pre-listing should be insisted on or there should be very close supervision of the listing operation in the field. (It would not be sufficient merely to check the order of listing by a field visit after the operation is completed.)

2.4.3 Grouping in space

The arrangements already described presuppose a sample of at least two stages. First, a sample of census enumeration areas or villages is selected, these constituting the PSUs. A secondary sample of households is then selected within each selected PSU.

In most countries, however, the PSU for which a sampling frame is available will be in many cases larger than a single village - in the sense of a single cluster of dwellings. Often the PSU will cover outlying hamlets and sometimes several villages. Clearly if the household sample is dispersed over such an area this will affect the number of households which the enumerator can visit in one day. The problem is particularly acute where a nutrition survey is combined with a budget survey: the enumerator cannot be asked to visit households in a different village or hamlet from the one in which he is observing his food consumption group and this severely restricts the sample design.

Various solutions have been attempted. In Lesotho, the solution is left to the enumerator: he is required to visit each sample household 4 times every month but it is not stipulated that he must go exactly once each week. With these flexible rules he is expected to work out his own itinerary. There is of course no nutrition survey involved in this case. In Upper Volta, the method was adopted of sampling a cluster of households, made up of a group appearing consecutively in the list. While this solves the problem it seems to go rather further than necessary and must introduce a considerable increase in sampling error - which, moreover, cannot be estimated.

As long as visits are not made daily to each household, the problem can be to some extent alleviated by allocating the sample households between the days in such a way as to minimize the enumerator's travel. For example, if 10 households are selected in the PSU and 5 are to be visited on each alternate day, we can choose, from the given sample of 10, a group of 5 which are in one half of the area for the

1st day and 5 from the other half for the 2nd day. If visits are made at 3-day intervals the method gives an even bigger advantage.

For a pure budget survey, without nutrition, this solution should be adequate in many cases. Exceptionally, for those PSUs which are particularly large in area, we may divide the PSU into smaller areas and select one of these at random within which the whole household sample for that PSU is to be selected.

Where a nutrition survey is combined with a budget survey, or where the only available area units for use as PSUs are excessively large, there may be no alternative but to adopt the latter solution systematically, that is, to add a 2nd stage of area sampling. In this case all the selected PSUs are subdivided into smaller area units each consisting of an area within which one enumerator can conveniently work - perhaps not much larger than 1 sq. km. for a combined nutrition-budget survey or about 5 sq. km. for a pure budget survey. A sample of these secondary area units is selected and one enumerator is allocated to each selected unit. The exact method of sampling is discussed in Section 2.4.4 below.

2.4.4 Self weighting sample

The standard method of sampling when one wishes to satisfy simultaneously the two requirements of self-weighting and fixed sample size within PSUs is to sample at the 1st stage with probability proportional to size (PPS) and to select a fixed number of secondary units in each selected PSU. This will only give a strictly self-weighting sample if the "size" used in sampling with PPS is measured in terms of the number of secondary units in the PSU. To apply this method in practice we therefore need to know, before sampling begins, the number of households in each PSU.

In nearly all areas of rural Africa, the only information available on the size of PSUs is the population at the latest census. If this were proportional to the current number of households there would be no problem. Two analysis, in Dahomey and in Sierra Leone, found very large departures from such proportionality. This may have been due to population movements between the census and the survey, or to variation between areas in the mean size of households, or to error. A similar analysis of data from Lesotho showed much smaller, but still substantial, discrepancies. Whatever the reason, the results suggest that self-weighting should not be assumed for the above sample design in African countries. 1/

1/ Self-weighting implies that each sample PSU should be given equal weight. If the true weights varied by 10 or even 20 per cent, it would be pedantic to object to the self-weighting assumption, for in almost any survey quite large errors in PSU weights have only small effects on the results. In Dahomey, the correct weights were computed for 78 PSUs. The highest weight was found to be 13 times as large as the lowest. This discrepancy appears too large to be ignored. Roughly comparable results were found in Sierra Leone. In both countries, the time interval between the census and the survey was about 2 years. In Lesotho, with a 1 year interval, the ratio of the largest weight to the smallest, among 47 PSUs, was 3.4 : 1. Variation in household size made only a very small contribution to this. (These ratios should have been 1: 1 in every case if self-weighting were to be strictly justified for the sample design mentioned.)

It is, however, easy enough to meet the self-weighting requirement in conjunction with the requirement of a fixed sample of households for each enumerator, if we allow that the number of enumerators in each PSU need not always be exactly 1. Two methods are available.

A. In the case (already discussed in Section 2.4.3) where secondary area sampling units (SSUs) are to be created in each selected PSU, the enumerator should record the number of households in each SSU during the household listing operation. SSUs then have to be selected with probability proportional to the ratio,

$$R = \frac{\text{Number of households in SSU}}{\text{Selection probability used in 1st stage of sampling for this PSU}}$$

This may be done as follows. All the SSUs created in the selected PSUs are listed and the value of the above ratio is entered against each.[1] This is multiplied by 1000 (or any other convenient factor to eliminate decimals) and cumulated. Then a systematic sample, with a random start, is selected from the cumulative column. One enumerator is assigned to each selected SSU. This method ensures a self-weighting sample with a fixed number of sample households per enumerator and also groups the enumerator's sample into a smaller area than the PSU. The only objection is that there may be no household sample in some selected PSUs and there may be two household samples (with two enumerators), or even three, in some PSUs, though they will be in separate SSUs. These cases will be rarer if PSUs were selected with PPS than with equiprobability; the former is therefore recommended.

1/ As we are concerned only with proportions, we can simplify the work by putting the PSU census population in the denominator of R instead of the selection probability. The selection probability is proportional to this.

B. Essentially the same method can be used without creating secondary area units. A household listing operation is carried out in the selected PSUs, which are then re-selected with probability proportional to the ratio

$$R = \frac{\text{Number of households in PSU}}{\text{Selection probability used in 1st stage of sampling for this PSU}}$$

This is done by listing the PSUs selected at the 1st stage with the above ratio entered against each,[1/] then proceeding as in case A above. The result will be that some PSUs will now be selected twice (even perhaps thrice) and some not at all. For each selection send an enumerator, and for each enumerator allocated to the PSU select a sample of the usual size (e.g., if it is desired to give each enumerator 10 households, then select 10 households where the PSU is selected once, 20 where it is selected twice, etc.)

It may happen that, in order to meet the needs of a demographic or other survey, a household listing is desired in a much larger sample of PSUs than is needed for the household survey. In this case the sampling with probability proportional to R, described above, will be carried out with probability kR where k is much smaller than before. This will now select only a subsample of PSUs, and if k is small enough there will be no cases of two enumerators allocated to the same PSU. This was the situation in the Cameroun rural surveys where method A was applied.

A further difficulty must now be faced which arises form the requirement that households be stratified with unequal sampling fractions in the strata. How can we ensure an equal household sample in each PSU, together with self-weighting within strata, in view of the unequal stratum sampling fractions and the unequal proportions of households in a given stratum in different PSUs?

1/ As we are concerned only with proportions, we can simplify the work by putting the PSU census population in the denominator of R instead of the selection probability. The selection probability is proportional to this.

A possible solution (which has not yet been applied in any African rural household survey) would be simply to follow the procedure outlined in A or B above except that, when counting the number of households in the SSU or PSU for the numerator of the ratio R, the households of each stratum are now weighted by the stratum sampling fraction. For example, if fractions in the ratio 1/2 : 1/5 : 1/10 are to be applied to three strata, then 1/2 should be counted for each household in the first stratum, 1/5 for each household in the second, and 1/10 for each household in the third. For the household-sampling itself in each area unit (SSU or PSU), first work out how many households would be selected in each stratum if the chosen sampling fractions were applied, sum to give the total households which would be selected in the area unit, divide by 2 if 2 enumerators are allocated to the area unit; this gives the number of sample households per enumerator in the unit. This now has to be adjusted up or down to conform to the enumerator's quota (= Q, say) which was decided in advance. The adjustment, for the area unit, is applied pro rata in each stratum in that unit and the sample is then selected in accordance with these adjusted sampling fractions. Mathematically, if N_h is the number of households in stratum h in the selected area unit, and f_h is the predetermined sampling fraction for stratum h, then use the sampling fraction

$$f_h \times \frac{Q}{\sum_h f_h N_h}$$

instead of f_h, in stratum h in that area unit, where Q is the predetermined enumerator's quota (10 in the examples given above).

This will lead to the required quota Q. If two quotas are required in the area unit, as will sometimes happen in method B, sample with twice this fraction. 1/

Example

We assume method A - creation of SSUs in each PSU.

Suppose census population of selected PSU was 1720 persons.

Suppose the listing operation in a certain SSU in this PSU reveals the following numbers of households by stratum:

Stratum 1:	40	households
.. 2	60	..
.. 3	90	..
	190	

Suppose sampling fractions for the strata have been chosen in the ratio $\frac{1}{2} : \frac{1}{5} : \frac{1}{10}$ for the 3 strata respectively (these will be the same for all PSUs).

Then R for this SSU is given by

$$\frac{\frac{1}{2} \times 40 + \frac{1}{5} \times 60 + \frac{1}{10} \times 90}{1720} = \frac{41}{1720} = 0.024$$

whence 1000R = 24.

List all SSUs in all selected PSUs, with the quantity 1000R against each. The SSU in this example will be listed with the number 24.

1/ The equivalent of this solution is described in the methodological report of the Cameroun rural surveys by G. Winter (op. cit.).

Cumulate these numbers and select systematically (with random start) in the cumulative column, with an interval such that the number of selectionswill equal the number of enumerators.

Suppose the above SSU is selected.

Suppose the quota of households per enumerator has been fixed at 10.

If we selected households from the 3 strata with sampling fractions 1/2, 1/5, 1/10, we would obtain a sample of $\frac{1}{2} \times 40 + \frac{1}{5} \times 60 + \frac{1}{10} \times 90$ = 41 households, whereas in fact we desire only 10. Thus we adjust these fractions by the factor $\frac{10}{41}$.

This leads to the following sample.

Stratum	Fraction	Number of households in stratum	Number selected	
			Theoretical	Rounded
1	$\frac{1}{2} \times \frac{10}{41} = \frac{5}{41}$	40	$\frac{5}{41} \times 40$	5
2	$\frac{1}{5} \times \frac{10}{41} = \frac{2}{41}$	60	$\frac{2}{41} \times 60$	3
3	$\frac{1}{10} \times \frac{10}{41} = \frac{1}{41}$	90	$\frac{1}{41} \times 90$	2
				10

To select 5 households out of 40 for stratum 1, we sample systematically (with random start) at an interval of 8 - after arranging the list of households for this stratum by order of size. Similarly, for stratum 2 the sampling interval will be $\frac{60}{3} = 20$, and for stratum 3, $\frac{90}{2} = 45$.

This procedure meets all the requirements regorously.[1] In practice, the varying stratum composition of different PSUs may lead to rather wide variation in the number of enumerators to be allocated to different PSUs.

NOTE The method described for sampling SSUs in A, or resampling PSUs in B, with or without the modification to take account of stratification, requires collecting the information on PSU or SSU populations at a central point for sampling. If this is not convenient and it is desired to carry out the selection locally in each area unit with probability kR [2], this can be done very simply as follows. Multiply kR by 10 and round to the nearest whole number. Let this be D. Select from a table of random numbers a number between 1 and 10, another between 11 and 20, another between 21 and 30 and so on until a number greater than D is selected. The number of these selections which do not exceed D gives the number of times the area unit (SSU or PSU) is selected. Of course if all of the random numbers selected exceed D then the SSU or PSU is not selected and there will be no household survey in this unit.

Another way of dealing with stratification without losing the self-weighting property would be to fix the strata limits differently in each

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1/ The sample is self-weighting within strata. It is not possible for a sample to be self-weighting over all strata if there are varying sampling fractions in the strata at the ultimate stage.

2/ Since kR may exceed 1, it would be more correct to say that we desire to select the area unit r times where r is to have mathematical expectation kR.

PSU and always in such a way that the proportion of households in each stratum is the same in every PSU - the method of "percentile strata". For example, one might create 3 strata, the 1st defined as the wealthiest 10% of households in each PSU, the 2nd covering the next 30%, and the 3rd the poorest 60%. This is only possible if one stratifies by some continuous variable, such as declared sales of produce, so that the strata limits can be fixed at any level desired; it would not work with stratification based on occupational categories. Further, the stratification would probably be a good deal less efficient: households in the 1st stratum in one PSU might be poorer than some households in the 3rd stratum in another PSU. This method has been used only once in Africa, namely in Sudan (1967).

Finally, a "solution" which would make sampling much simpler would be to abandon the self-weighting requirement. If all of the tables are to be produced by electronic computer, the weighting would not be excessively laborious. 1/ If this arrangement were adopted, the simplest sample design would be as follows. First select PSUs with equal probability. If further grouping of the sample is necessary in order to limit enumerators' travel, create SSUs in each selected PSU and select 1 in each PSU. Within each selected area unit (SSU or PSU),

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1/ Before deciding in favour of data-processing by electronic computer it is advisable to investigate very carefully the capability of the computer installation concerned and of its attendant staff. Experience both in Africa and Europe has shown that electronic processing of ad hoc operations such as surveys may involve very long delays, particularly at the programming stage.

select a fixed number of households in each stratum, these numbers being the same in every area unit. They would total to the desired enumerator's quota and there would be one enumerator in each sample PSU. The correct weighting would have to be computed for every stratum in every PSU: it equals the reciprocal of the product of the 1st and 2nd stage sampling fractions. These weights could be grouped into a small number of weighting classes (e.g. any weight between 250 and 349 could be rounded to 300), without danger of serious error, provided external raising factors are applied in the event that estimates of totals are required (see Section 2.1.3).

If stratification is not used, the variation in weights would be considerably smaller and perhaps 4 or 5 weighting classes would suffice. In this case a non-self-weighting sample could be processed without too much difficulty even without an electronic computer. It is a matter of opinion whether in this case simplification of the sample design by selection of a fixed sample of households in every PSU would be preferable to the saving of labour at the data-processing stage.

The possibility of obtaining a self-weighting sample without any of the complications mentioned above, simply be relaxing the requirement of a fixed household sample per enumerator should also be mentioned. With a nutrition survey this solution may reasonably be rejected outright. With a budget survey it is worth considering. Clearly in practice an enumerator does not work to such fine limits that another household or two cannot be squeezed into his quota. On the other hand, it has to be admitted that if any enumerator works below the standard quota this is a definite waste of resources. To set an arbitrary, though generous, limit, we might fix the maxim flexibility in the enumerator's sample as a deviation of $\pm$ 50% from the standard quota. Unfortunately it is very doubtful whether this requirement could be met without using the devices described earlier in this section. As regards the adjustment for PPS sampling due to the inadequacy of census data, for

the three countries mentioned for which data are available it is known that if the adjustment were ignored some enumerators' samples would go outside the limit ± 50%. As to the adjustment for varying stratum composition of selected area units, it seems likely that this too could not be ignored without excessive variability in the sample size for different enumerators.[1/] Thus it seems necessary to reject this approach.

Summary of Section 2.4.4

Two factors make it difficult to have a self-weighting sample and at the same time to get a fixed quota of households for each enumerator:

1) Inadequacy of census data for EAs or villages. Evidence shows that census population figures are far from proportional to the current number of households in each EA.

2) Varying stratum composition (i.e. varying proportions of rich and poor) in different areas. This causes difficulty only if it is desired to apply unequal sampling fractions in the household strata.

Factor (1) can be overcome in either of two ways. In both, it is assumed that PSUs are first selected with PPS, using the census data, then households are listed and counted in each selected PSU. The two methods are:

A. Create SSUs in the selected PSUs. Select these with probability proportional to $\hat{R}$ (defined on p. 30). Then select the desired quota Q of households in each selected SSU.

1/ There are no numerical data available but one can consider hypothetical examples. If in one PSU the proportion of households in the two wealthier strata were twice the norm, the enumerator would be assigned over 50% more households than the standard quota provided the sampling fraction in the third stratum were less than one-third of that in the second stratum. (It is assumed that the rules mentioned in Section 2.3.2 are being followed.)

B. Re-select the selected PSUs with probability proportional to R (defined on p. 31). This will result in some of the PSUs originally selected being now rejected; others will be selected twice, possibly thrice. For each such selection, select a quota Q of households. Send 1 enumerator for each quota Q.

Either of these solutions completely solves the problem created by (1). The penalty is a more complex sampling procedure and a less even distribution of enumerators.

If stratification with unequal sampling fractions is desired, factor (2) creates a problem. This can be solved by a modification of methods A and B, in which the ratio R is given a weighted numerator. The data for this come from the listing operation, in which stratifying information is collected. Such information may be collected for all the households in the selected PSU or only for a sample.

This completely solves the problem created by (2), but at the expense of further complexity in the sampling and still more uneven distribution of enumerators.

Alternatively, factor (2) can be overcome by the method of percentile strata. This avoids the further unevenness of distribution of enumerators but at the expense of less efficient stratification.

In preference to any of these solutions we might prefer to relax one or other of the requirements and to simplify the sampling. Thus:

Self-weighting sample. If this requirement is dropped, data-processing becomes more complex. This can be palliated (but not prevented) by grouping the weights. If we have to deal with factor (1) only, the resulting data-processing requirement might be feasible on conventional equipment. If we have stratification with unequal sampling fractions, then factor (2) enters as well and probably the wider variability of the weights would then make electronic processing mandatory.

Fixed sample for every enumerator. Relaxing this requirement would not enable us to abandon the relatively complex sampling methods suggested above without an inadmissible amount of variation in the enumerators' work-loads. This solution therefore appears to be unacceptable.

2.4.5 Integration of nutrition survey with other objectives

We have already considered the time sampling requirements for a nutrition survey and the effect these have on the sample design. Briefly, one household, or more strictly "food consumption group", is visited 2 or 3 times a day for 5 - 7 days, after which the process is repeated for a different food consumption group in the same village, and so on until the end of the period of continuous recording for budgets. At the same time budget recording can be carried out in 2 or 3 other households each day, provided they are in the same small area of the order of 1 sq. km. Thus in the typical survey the nutrition sample requires selection of 4 food consumption groups in each SSU or PSU, and in nearly all cases the creation of SSUs will be mandatory in order to concentrate the sample within small enough areas.

How is this sample to be selected within SSUs at the same time as the budget sample while fulfilling the requirements of self-weighting and fixed sample size per enumerator?

Two methods which will not satisfy the requirements are: (i) To carry out the sampling of units for the nutrition survey, in each selected PSU, entirely independently of the sampling for the budget survey. This would not work because the ratio R would be different for the two surveys. (ii) To add the nutrition sample as an extra stratum. This would not give a fixed number of nutrition households selected in each PSU.

The only method which meets (or nearly meets) the requirements appears to be to assign the nutrition survey to a subsample of the households selected in the manner already described in each PSU.

This has two drawbacks. Firstly, the units for the two surveys - budget groups and food consumption groups - do not always coincide. It is presumably the former that will be listed and sampled. We then have to select from the sample of budget groups a subsample of food consumption groups. Cases of discrepancy between the two types of group will have to be dealt with as follows. If members of the budget group selected in the subsample eat meals in more than one food consumption group, we select one of the latter at random. If, as will be more common, the selected budget group forms only part of a food consumption group, the latter is selected. Any selected food consumption group then has to be weighted at the data-processing stage by the factor $1/g$, where g is the number of budget groups participating in this food consumption group. In practice g will probably be 1, 2 or 3 in every group, so that the amount of re-weighting may not be large. However, in so far as g is not constant the self-weighting property is lost.

A second drawback is that the nutrition sample will have the same unequal strata sampling fractions as the budget sample. In most nutrition surveys we have no special interest in the wealthier households and we would prefer to give all households equal weight. At the cost of some complexity it would be possible to achieve this by cancelling out the strata sampling fractions by using the reciprocal of these fractions when subsampling for the nutrition sample. Besides the additional complication at the sampling stage, there would be the need to re-weight the nutrition sample during processing. But if one is prepared thus to ignore the self-weighting requirement it would be simpler to return to the first suggestion made in this section: to carry out the sampling of food consumption groups, in each sample PSU,

entirely independently of the sampling of budget groups. In this case, both groups should be listed at the household listing stage.[1] The budget sample is stratified and selected as described in earlier sections. For the nutrition sample a fixed number (4 in the examples quoted above) of food consumption groups is then selected with equal probability. The nutrition sample will require an individual weight for each PSU, but there will no longer be any need to allow for the failure of the two types of unit to coincide. The budget sample can still be self-weighting. It should be noted that the problem raised in this paragraph arises only if household stratification with unequal sampling fractions is used for the budget sample.

One further requirement should be noted. Where a nutrition survey and a budget survey are carried out at the same time, it will generally be desired to relate the two sets of data for the same household (or as nearly the same as the difference in the units allows). This means that budget recording will have to be carried out for each sample food consumption group (or for the budget group most closely related to it). If the two types of group are sampled quite independently within the same PSUs, the budget data for the food consumption groups will not fit into the sample of budget groups without special weighting. They should be given the same weight as the food consumption groups before being added to the budget sample.

2.4.6 Sampling efficiency and cost

While sampling efficiency is in principle important it has no role to play as an independent factor in the survey design - that is

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1/ This might present considerable difficulty for enumerators. It would be advisable to test the procedure carefully in a pilot survey.

to say, there is no point at which we are free to adjust some parameter to give optimum efficiency without paying any penalty.[1] This is because once the time sampling arrangements have been fixed this determines the whole sample design - with the exception of the total sample size.

To say this is not to imply that sampling efficiency can be ignored in drawing up the survey plan. On the contrary, it has to be very seriously considered, but this will be in the earlier stages of planning, when the survey objectives are being fixed and the main time-sampling parameters being chosen.

The key question here is the frequency of the enumerator's visits and the way this is determined by the survey objectives. At one extreme there is the pure budget survey, concerned only with monetary transactions. In rural areas information of this kind might reasonably be sought by visits every second or third day. The enumerator can then handle some 10 - 15 households which can be spread out over a comparatively large area such as the typical EA. At the other extreme is the nutrition survey, requiring 2 or 3 visits per day and allowing the enumerator time to visit 2 or 3 other households for budget recording. If it is assumed that the nutrition household is also surveyed for budgets, this leads to a total sample of 5 - 10 households for budgets per enumerator which must be grouped in a very small area. Both the smaller sample and its greater concentration will mean a lower sampling precision for the budget survey. Very roughly, the effect of the nutrition survey will be to double the field costs of the budget enquiry for a given level of sampling error.

1/ In other types of survey the situation is different. For example, in demographic or health surveys we can adjust the sample size within PSUs on the sole criterion of optimal cost efficiency.

Many surveys are concerned not with monetary transactions alone but also with recording of consumption of home produce (subsistence consumption). It seems unlikely that this can be accurately recorded without daily visits. If daily visits are made by each enumerator to one household for this purpose for one week, this household being changed each week, and budget recording is carried out each day for this household and for 4 others, each of the latter being visited once every 2 or three days, we get a total budget sample of 9 - 13 households, which have to be in a small area. This would perhaps be about 20% more costly in the field than the pure budget survey.

Finally, it should be noted that if a nutrition survey has to be carried out, then there is a negligible increase in field costs if a budget survey is added to it, since the enumerator cannot in any case handle more than one nutrition household at a time.

Another way in which the survey objectives influence the sampling precision attained for given cost is in the matter of repeat visits and rotation of the sample. If repeat visits are introduced (see Section 2.2.4), this enables seasonal variation to be more efficiently estimated and allows estimation of the distribution of annual income and cross-tabulation of annual income by other variables; at the same time, averages per household, and aggregates for the household sector as a whole, are less efficiently estimated.

It is obviously of primary importance to consider these various relationships between survey objectives on the one hand and costs or efficiency on the other when planning a survey. At the same time, the total size of the sample must be decided at this stage, in terms of the available resources of finance and manpower. A rational decision can then be taken on the objectives to be set for the survey.

2.5 Sample design for rural household surveys: summary

The following is a simplified presentation of the main decisions and operations involved in selecting a sample for a rural African household survey. Methods typically used in the past or recommended for the future are indicated. Where the two diverge, the recommended solution is shown. References to earlier sections of this paper are given and these should be consulted for details.

Note that considerations of cost and sampling error are not mentioned explicitly. These factors are affected by nearly all of the decisions listed, which in turn are mainly influenced by the survey objectives. Thus, savings in cost, or increased sampling efficiency, depend mainly on limiting the survey objectives (see Section 2.4.6).

A. DECISIONS

	Decisions required	Typical or recommended solutions	Consult section of this paper
D1	Type of survey	Budget only Budget plus non-monetary transactions 1/ Budget plus non-monetary transactions 1/ plus nutrition Nutrition only	1.1 2.4.6
D2	Geographical coverage	Regional	1.1
D3	Number of enumerators = E	Depends on resources; typically 20 - 50	-
D4	Total time coverage	1 year	2.2.1
D5	Primary period of continuous recording per household	Budget: 1 month Nutrition: 5-6 days	2.2.2
D6	Repeat periods: number and frequency.	None, 1 or 2, depending on survey objectives, at equal intervals over total survey period.	2.2.4
	This and D4 determine number of PSUs per enumerator = P.	P = 12, 6 or 4	-
D7	Return visits for retrospective questioning: number and frequency.	Between periods of continuous recording, 1 per month or per 2 months.	2.2.4
D8	Frequency of visits during period of continuous recording	Budget: once every 1, 2 or 3 days Consumption: daily Nutrition: 2 or 3 times daily	2.2.3

1/ Generally includes consumption of home produce.

	Decisions required	Typical or recommended solutions	Consult section of this paper
D9	Enumerator's daily quota of household visits. With D8 and system of rotation among nutrition households, this leads to choice of Q, enumerator's quota per village. With D3 and D6 this fixes total sample = E x P x Q households.	Budget survey without nutrition: 5. Q = 5–15 (depending on D8). Nutrition alone: 1. Q = 4. Combined: 2–3 budget, 1 nutrition. Q(bud.) = 2–9, Q(nut.) = 4.	2.4.1 2.4.6
D10	Choice of area unit for use as PSU	Village or EA	2.1.1
D11	Are smaller area units required within PSUs?	Usually yes if daily recording involved.	2.4.3
D11.1	If not, should only a sample of households be listed in each PSU, or all households?	Usually sample (assuming no to D11) unless associated demographic survey requires complete list. Note need for close supervision of sampling.	2.4.3
D12	Is household stratification with unequal sampling fractions desired? If so, choice of relative sampling fractions f_h.	Depends on survey objectives. Fractions in ratio 1:2:5 or 1:3:6 or 1:3:8 would be acceptable (larger values in wealthier strata).	2.3.2
D12.1	Are any types of household to be excluded? Do any require a special sampling fraction?	Depends on survey objectives. Consider non-farming households.	2.3.2
D13	Choice: self-weighting sample versus simplified sampling with 1 enumerator in every PSU Note. Choice can be different for budget sample and nutrition sample in same survey.	Self-weighting unless tabulations to be performed by electronic computer. But if there is to be no household stratification, a non-self-weighting sample with grouped weights would be manageable even without a computer.	2.4.4

Decisions required	Typical or recommended solutions	Consult section of this paper
D14 Demographic survey incorporated at listing stage? If so, the following decisions affect the household survey:	Usually yes	
D14.1 No. PSUs in demographic sample. If this exceeds no. in household survey sample, distribution of enumerators for latter will be improved.	Depends on available funds and personnel.	2.4.4
D14.2 Sampling fraction for households within PSUs. See also D11.1.	See paper E/CN.14/SM/3 of present seminar	

B. OPERATIONS

		Consult section of this paper
Op1	Stratify all PSUs in survey domain by type of region and main ethnic group.	2.3.1
Op2	From the list of PSUs rearranged in strata, select by systematic sampling with PPS a sample of PSUs equal in number to P (see D6) times the number of enumerators (or greater, see D14.1).	2.4.4
Op3	Send enumerators to the selected PSUs to list all households, or every household in every nth house (see D11.1), collecting information for stratifying households if desired (see D12).	2.3.2 2.4.2
Op4	Create area SSUs in each sample PSU if desired (D11), recording number of households (see Op7) by stratum ($= N_h$) in each SSU.	2.4.3
Op5.1	If self-weighting sample desired (D13):	
	Select SSUs, or re-select PSUs, with probability proportional to R, to show number of enumerators' quotas to be allocated to each, where $R = \frac{\text{No. of households in SSU or PSU}}{\text{Census population of PSU}}$ [1]	2.4.4
	Note. If household stratification used with unequal sampling fractions, weight households by stratum sampling fractions in computing numerator of R.	
Op5.2	If non-self-weighting sample desired (D13):	
	Select 1 SSU at random in each selected PSU and allocate 1 enumerator's quota to this. If SSUs not required (D11), merely allocate 1 enumerator's quota to the PSU.	2.4.4 2.4.3

1/ SSU if SSUs have been created, otherwise PSU.

	Consult section of this paper
Op6 In each selected area unit (SSU or PSU), arrange the household list in order of household size within strata and select a systematic sample1/ as follows:	2.3.2
Op6.1 If stratified self-weighting sample desired (D12, D13):	
Select with adjusted sampling fraction $f_h \times \frac{Q}{f_h N_h}$ in each stratum h, or twice this where 2 enumerators are allocated.	2.4.4
Op6.2 If stratified non-self-weighting sample desired (D12, D13):	
Select predetermined numbers of households in each stratum, namely $\frac{f_h Q}{f_h}$	2.4.4
Op6.3 If no stratification desired (D12):	
Select Q households.	2.4.4
Op7 If nutrition survey to be combined with budget survey (D1):	
Either select a subsample of fixed size in each PSU by systematic sampling1/ from the sample selected in Op6. If unit selected covers 2 food consumption units, select 1 of these at random. Note number g of budget groups in each selected food consumption group, the latter to be weighted by 1/g at processing stage.	2.4.5
Or list food consumption groups in Op4 and sample them by method of Op6.3 independently of budget sample.	

1/ Vary the random start systematically between PSUs.

		Consult section of this paper
Op8	In Op6.1, if 2 enumerator's quotas are selected, allocate these to the enumerators so as to minimize travel.	2.4.3
Op9	Allocate the selected PSUs (and /or SSUs) to enumerators taking into account the need for return visits (D7), repeat periods of recording (D6) and the needs of supervision and minimum travel costs.	2.4.1
Op10	Work out each enumerator's travel schedule so as to minimize travel and to avoid systematic movements by large groups of enumerators.	2.4.1

3. URBAN HOUSEHOLD SURVEYS

3.1 Sampling units and sampling frames

Three types of sampling units are of interest: area units, units of housing or property, and households. The availability of suitable sampling frames for each of these will be considered in turn.

3.1.1 Area units

In urban household surveys it cannot be assumed that area units for the first stage of sampling will always be necessary. There are two distinct reasons why they may be introduced.

i) In order to group the enumerators' samples. This is desirable not merely to reduce the time spent travelling between households, but also to facilitate supervision. For the latter purpose it is an advantage if the supervisor can be sure of finding the enumerator within an area of some 30 or 40 dwellings. If E is the number of enumerators and P the number of separate quotas of sample households allocated to each enumerator over the whole period of the survey[1/] then this can be achieved without grouping the sample provided the town contains not more than 40 x E x P dwellings. E may range typically from 20 to 30, P from 5 to 10 (see Section 3.2.6), and the number of persons per dwelling from 5 to 10. This kind of calculation is of course very rough, but it suggests that an initial stage of area-sampling will begin to become advantageous for towns larger than about 50 000 population (a more exact figure can be worked out for any given city and survey design from the above formula).

1/ Excluding repeat quotas of the same households. By a quota is meant the sample households allocated to one enumerator at one time.

ii) An initial stage of area-sampling may also be introduced in order to reduce the labour of listing dwellings or households to provide a sampling frame for the next stage. Generally such a listing operation would be considered prohibitive if more than a few thousand dwellings had to be listed. This limit corresponds to a population figure of perhaps 20 000 to 30 000, which is smaller than that given in the preceding paragraph. Thus we may take it that in a town of over about 25 000 population, if there is no sampling frame of housing or households an area-sampling stage will be required.

We now consider the availability of area-sampling frames in African towns.[1/]

Most large African towns have been covered by a complete census during the last 10 years. Such an operation commonly leaves behind a legacy of a well defined structure of enumeration areas (EAs) which are generally suitable for sampling purposes, at least in the larger cities. In the smaller towns (perhaps under 10 000 population), such units may not be sufficiently numerous for satisfactory sampling: a sample of less than about 20 area units cannot be expected to give an adequate representation of the whole town and the ideal number in the sample would be one per enumerator per period, i.e. E x P, which will generally exceed 100.

Many African towns also have available large-scale aerial photographs or detailed maps which enable blocks to be marked out which can be used as area-sampling units. In general, such units have the disadvantage that their populations are not known even approximately; but in some cases rough population estimates can be obtained by counting

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1/ The discussion to the end of 3.1.3 follows, with some modifications, that in Section 4.1 of the paper for this seminar Sampling for Demographic and Housing Surveys and Civil Registration, E/CN.14/SM/3.

buildings observed in the photograph or map and multiplying by an estimate of the ratio population/buildings obtained from the latest census for each district of the town. Such estimates can be used either directly for sample raising (ratio estimation) or for creating blocks of approximately constant size.

3.1.2 Units based on housing and property

In most African towns there are numerous conceptual difficulties in defining units based on housing, and this means that it will generally be troublesome to try to sample from lists of such units obtained during a census. Sampling buildings from aerial photographs is even less practicable, both because of the difficulty of defining precise units and because enumerators have difficulty in pin-pointing on the ground structures seen in an aerial photograph.

A few African towns, however, are laid out in a simple grid pattern which leads directly to clearly defined spatial units of property, or "lots". Brazzaville and Kinshasa are notable examples, where the lots are termed parcelles. Such units may be sampled from aerial photographs, from census records (Brazzaville) or from municipal registers (Kinshasa). In some towns this may be possible in certain districts only (Khartoum, Omdurman).

Finally, in many African towns even where lay-out is unsystematic, municipal records exist which are claimed to cover every inhabited building. This claim should be checked in the field before such records are accepted for sampling purposes.[1/] If they are found adequate they lead to a unit which may be called the house number - a unit of housing to which the municipality has allocated a number. In most towns

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1/ In the paper for this seminar E/CN.14/SM/3 it was suggested that municipal house-lists should also be checked to see whether selected units can be rapidly traced on the ground. This requirement, recommended in the context of a demographic survey, would be less important for a household survey, where the sample is much smaller and the initial visit to the selected units forms only a small fraction of the whole field operation.

where there is no systematic lay-out such units will be highly variable in size and this will be a disadvantage for sampling purposes.[1]

There remain many African towns where no suitable housing sampling frame is available and in this case it is necessary to create one (or possibly a household frame, see Section 3.1.3) by sending enumerators to list dwellings, either throughout the town or within an area sample. For this purpose the listing unit should be chosen so as to be a clearly distinguishable unit, in no case cutting a household in two, and preferably not much larger than the living quarters of a single household. The unit satisfying these conditions will be different in different towns - and quite probably in different districts of the same town. As a convenience we shall call it in this paper the dwelling, though it will not always correspond to the unit defined as a dwelling in the United Nations Principles and Recommendations for the 1970 Housing Censuses.[2]

3.1.3 Household lists, tax lists, etc.

Household lists as such are rarely available for African towns. The census is unlikely to be useful as a household list, because of the high mobility of households and also in most cases the lack of precise addresses.

In a number of countries tax lists are available which are supposed to cover the whole urban population. This claim should be checked by a small sample field operation before such lists are used for sampling. Even if the list is found to be complete, there may be difficulty in converting it from a list of taxpayers into one of households.

1/ It may be noted that where house numbers exist and where it is desired to use some other unit of housing, it is sometimes difficult to persuade enumerators not to work on the basis of house numbers.

2/ Sales No: 67.XVII.4. Definitions are given in this publication in order to encourage uniformity of reporting. For the present purpose we are concerned with sampling units, which will not in general be used for reporting.

Where the survey is limited to wage-earners, lists may be obtained from employers and this method has often been used in English-speaking African countries. In French-speaking countries social security or other official records have sometimes been used. In both cases such records may be incomplete, and they are not of course adequate for the comprehensive type of survey covering the whole urban population.

It might be supposed that, since the unit of enquiry is the household, a list of households could be prepared by a field operation within a sample of area units, without passing through the stage of sampling dwellings. In fact, however, the dwelling seems to have been used as a sampling unit in almost every African household survey covering the general urban population. This is partly because lists of dwellings are often available, partly because, even where they are not, dwellings are much easier to list than households, and partly because of the great instability of households in urban Africa which means that a sampling frame of households goes out of date in a few months. The relevance of household mobility to sample design will be discussed in more detail in Section 3.4.

In some surveys the dwelling has been the ultimate sampling unit, the survey then covering all households in the selected sample of dwellings. In other surveys the households in the sample dwellings have been listed and a sample of these households selected.

There are two advantages of stopping the sampling at the dwelling stage. Firstly, the dwelling is a more sharply defined unit than the household (or rather, than the budget-group, which is the unit of enquiry). Strictly speaking it is impossible to be sure who belongs to the budget-group until some information has been collected on the group's transactions, and in practice one sometimes needs to revise the membership of the group after the first few days of budget recording. In particular, where two groups inhabit one dwelling there is likely to be doubt as to the exact division between them. These problems are eased if the survey covers all persons living in the dwelling. Secondly,

if there is to be an additional household sampling stage this means some additional work in listing and sampling. On the other side, we shall see in Section 3.3.2.2 that stratification is less efficient if there is no household sampling.

A decision on this question should depend on how closely the dwelling corresponds to one household. If the average number of households per dwelling is less than about 1.5, the arguments for using the dwelling as the ultimate sampling unit are probably over-riding. In most cases where a sampling frame of housing exists the units will be larger than this, and then household sampling becomes desirable.

3.2 Time sampling

Many of the time sampling requirements for an urban household survey are similar to those for a rural survey. For this reason, frequent reference will be made in the present section to Section 2.2 and only the differences between the urban and rural cases will be discussed in detail.

An important distinction must be made at this stage. Many household surveys in urban areas have as their essential objective the determination of weights for a consumer price index. Variations in such an index are generally very insensitive to errors in the weights, so that a survey of this kind has much less stringent needs for accuracy than the more elaborate type of survey with wider objectives which has been attempted in many African cities. As a convenient short-hand, we shall refer to these surveys as light-weight and heavy-weight respectively.

Generally speaking, light-weight surveys have been commoner in English-speaking countries and heavy-weight in French-speaking, and this has led to considerable divergences in the approach to urban household surveys in the two sets of countries. In the present paper more attention will be given, inevitably, to the heavy-weight type of

survey because these present more difficult problems, and the simplifications which can be made for the light-weight survey will generally be obvious. This is in no way intended to imply that heavy-weight surveys are more desirable; this is a controversial question which falls outside the scope of the present paper - though not, it is hoped, of the present seminar.

A further broad difference between the rural and urban sectors is that nutrition surveys are relatively rare in urban areas, and when they are carried out they are usually independent of any budget survey. The importance in the urban sector of meals purchased and consumed outside the home makes collection of accurate nutrition data extremely difficult and this is no doubt the main reason for the above difference.

In the remainder of this section we discuss in turn the following aspects of time sampling:

3.2.1 Total period of the survey

3.2.2 Period of continuous recording

3.2.3 Frequency of interview and time reference of the interview

3.2.4 Rotation and renewal of the sample; return visits after an interval; retrospective questioning.

3.2.5 Staggering of enumerators' starting dates.

In a final section 3.2.6 we consider the total sample size.

3.2.1 Total period of the survey

Seasonal variation in consumption and expenditure in urban areas tends to be considerably less than in the rural sector. Nevertheless it is still not negligible; this is obvious as regards local foods, but perhaps less obviously there may be important variations in all kinds of purchases in relation to popular festivals (such as Christmas) or periods of abstention (such as Ramadan). It is perhaps only for the light-weight type of survey that these variations can safely be ignored and the survey limited to a short period. Many light-weight surveys

have run for 3 months, but nearly all heavy-weight surveys have continued for a full year.

The availability of field staff affects the total survey period. If teachers or students are used as field-workers, then the survey must, in most cases, be limited to a short period. Where professional enumerators are used a long survey period is often more convenient: it implies a smaller number of enumerators, which makes recruiting easier and training cheaper, and it also enables a given number of senior staff to supervise a much larger field force. Since the bottleneck in most surveys is the number of senior personnel available for field supervision this may be an over-riding factor in favour of a long survey period.

An obvious disadvantage of a long survey period is the longer interval it implies between the start of work and the publication of results.

It will be seen in Section 3.4.1 that the length of the total survey period has a bearing on the sample design in that a long period leads in practice to a greater dispersion of the enumerators at any given time, with a consequent lack of flexibility in the allocation of households to enumerators.

3.2.2 Period of continuous recording in one household

In urban areas there is generally a very sharp variation in expenditure in relation to pay-day. An analysis of the records of the Yaoundé survey of 1964-5 showed that expenditure on goods and services by wage-earners on pay-day and the three following days rose to a level about twice that of the average computed over the whole of the month. If loan repayments are included, the level on and just after pay-day was nearly three times the average level.

In theory this suggests that the most efficient way of sampling would be to stratify the time-sample with varying sampling fractions, using a higher sampling fraction during the pay-day period than the rest of the month. However, analysis of the Yaoundé data showed that this would increase sampling efficiency by no more than 12%, and this is certainly not enough to justify the added complexity of such a procedure.

In the majority of African surveys, urban as well as rural, each sample household has been surveyed continuously for a period of approximately 1 month. This has two important advantages:

i) The natural periodicity being 1 month for income and expenditure, by observing the whole of such a period we are able to draw up a monthly account for each household, whose approximate balance provides a useful check against gross omissions or mis-statements.

ii) An important purpose of the heavy-weight type of budget survey is to investigate how expenditure patterns of households vary according to their income. Precise classification of households by income requires at least 1 month's observation of each household.

These advantages are probably over-riding as regards wage-earning households, though they hardly apply to non-wage-earners.

On the other hand, if one of the purposes of a budget survey is to assess total or average income or expenditure of households (data which would be needed, for example, for fixing weights for a consumer price index) there can be little doubt that to follow each household for a month is an inefficient sampling procedure, particularly for

non-wage-earning households.[1]

While the position is somewhat complex, the optimum varying both with the nature of the expenditure and the employment status of the household, a reasonable rule to follow would perhaps be the following:- Use a period of 1 month normally, but consider using a shorter period for a light-weight survey, and for non-wage-earners in a heavy-weight survey. In several light-weight surveys a period of 1 week has in fact been adopted (e.g. Freetown 1961, Mogadiscio 1966).

The use of a shorter period for non-wage-earners need not necessarily cause much inconvenience in practice. Indeed, in the plan for the Libreville budgets survey of 1967-8 mentioned in Section 3.4.2, the reduction of the recording period from 4 weeks for wage-earners to 2 weeks for non-wage-earners actually simplified the sampling method.

Reference should be made to Section 2.2.2 for discussion of other factors affecting the choice of the period of continuous recording.

3.2.3 Frequency of interview and time reference of the interview

In nearly all urban household surveys in Africa, households have been visited at least once a day by the enumerator.[2] Purchases are of

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1/ Another analysis of the Yaoundé data showed that for food purchases the 30-day period was from 4 to 5 times as costly for given sampling error as a 3-day period for purposes of estimating averages and totals. For most items of expenditure other than food this advantage of a short period was limited to non-wage-earners, there being no advantage in the case of employees and professional classes.

2/ An exception is the 1963 survey of Asmara, where visits were made every second day. In the 1961-2 urban surveys in Madagascar, visits were made on a weekly basis but the respondents were asked to record their purchases daily in a specially prepared booklet. This is the method generally used in developed countries. There is, of course, no guarantee that the entries are in fact made on the day of the transaction concerned. In several African urban surveys, notably the long series in Nigeria, a notebook has been left with the respondent for recording of purchases, but the enumerator has nevertheless made daily visits to the household to transfer the data on to a record sheet.

course much more frequent than in the rural sector and the possibility of a longer interval has generally been assumed to be excluded by the unreliability of respondents' memory. For evidence supporting this conclusion reference should be made to Section 2.2.3.

In many urban surveys in French-speaking countries the enumerator has been instructed to make two visits per day to each household, one at mid-day to catch the housewife on her return from the market and one in the evening when it is hoped to find the head of household at home. This procedure seems certain to improve the accuracy of recording. Moreover, it is in any case essential to see the principal male of the household each day and for this purpose almost every household has to be visited in the evening. Thus if the mid-day visit is not insisted on the only result is to leave the enumerator under-employed at mid-day; it does not permit any increase in the number of households interviewed per day.

3.2.4 Rotation versus renewal of the sample; return visits after an interval; retrospective questioning.

In theory, the position in regard to sample renewal, return visits and retrospective questioning is very little different in the urban sector from the rural, and reference should be made to Section 2.2.4. The smaller extent of seasonal variation in the urban sector reduces the force of one of the arguments in favour of return visits, but there remain the arguments that estimates of annual income for each sample household are needed for the income distribution and for cross-tabulation with other variables, and that repeat visits enable the retrospective method to be supplemented by the method of comparing inventories. Perhaps only in the light-weight survey can these considerations be ignored.

In practice, among urban surveys, repeat visits to the same sample of households have been reported only in the survey of Yaoundé, 1964-5. Here it was found that the correlation between expenditures recorded for the same household during the two survey months (separated by an interval of 5 months) was remarkably low.[1] This finding emphasizes the need to make several months' observations of each household if it is desired to estimate annual income. It also implies that the procedure of repeat survey periods in the same households would only entail a small loss of sampling efficiency for the estimation of totals and averages. Thus there would appear to be a good case for modifying current practice and introducing such repeat periods in urban surveys.

On the other hand, intermediate short visits to households between periods of continuous recording hardly seem justified in the urban sector. In the rural sector such visits have been used for retrospective questioning to fill in the gaps between the continuous recording periods and thus to build up a complete picture of each household's annual budget. In urban areas, where incomes are more stable, it would probably be sufficient to estimate the household's annual budget from two or three continuous recording periods of a month each, regarded as a time-sample representing the total 1-year period.

1/ This is not the only evidence of remarkably low levels of employment stability in Africa. A recent study in Congo (Brazzaville) showed that among wage-earners (other than civil servants) who were employed at some time during 1965, only 58% had worked for the full calendar year in the same establishment. (Direction du service national de la statistique, Les salariés des entreprises en 1965, Brazzaville, 1966.)

3.2.5 Staggering of enumerators' starting dates

In many urban surveys in French-speaking countries, arrangements have been made to stagger the starting dates of different enumerators - that is, to arrange that the periods of continuous recording of different enumerators start at different dates. At the same time, in many surveys the cyclic period for each enumerator has been deliberately made different from an exact calendar month, with the result that over the whole period of the survey the starting dates for different households have been distributed approximately randomly over all days of the month.[1/] On the other hand, in several countries the cyclic periods have been exactly 1 month and synchronized for all enumerators (usually from the middle of one month to the middle of the next, in order to be sure of covering pay-day).

Arguments in favour of staggered starting dates are the following:

i) It is often considered desirable for the survey organizer to accompany the enumerator for the initial visit to each household in order to reassure the household, deal with any difficulties, and give the enumerator any special instructions which may be necessary in individual cases. Clearly staggered starting dates are a necessary condition for such visits to be feasible. Even if such visits are left to the regular field supervisors, a minimum of staggering still seems necessary since one supervisor is generally responsible for 20-30 households at any one time.

1/ However, during any one cycle for any one enumerator, the starting dates will always be the same for all the households of this enumerator's quota. Any other arrangement would clearly waste the enumerator's time.

ii) Similarly, a visit to the household by the organizer at the end of the period may help in clearing up inconsistencies, checking omissions, etc.

iii) It is not possible for enumerators to work every single day of a period of several months. Gaps are needed for holidays and also, where the survey lasts for more than 2 or 3 months, for listing operations designed to prepare household sampling frames and for the sampling operation itself. (The high mobility of households may make it impracticable to prepare a single frame in advance of the survey.) A further gap of 1 day between each cycle is almost essential for introductory visits to the sample households; at these visits much time has to be spent on explanations and collection of background information and it is not convenient to collect budget data at the same visit. Finally, some authorities consider it advisable to discard the first few days' data for each household on the grounds that reliable information is only given after a running-in period.[1/] All of these gaps imply that, if an attempt is made to have enumerators work in unison, with a monthly cyclic period, the monthly totals will have to be made up by some kind of extrapolation process. The wide within-month variations of daily expenditure and the effects of festivals may then lead to substantial error unless the gaps can be kept down to 2 or 3 days per month. However, one way of doing this is to have the listing and sampling operations performed by a separate team and to ignore the requirement of rejecting the first few days' data (few surveys have in fact rejected such data).

1/ An analysis of the Yaoundé data showed that the first 3 survey days in each household gave very different figures from the rest of the period. Reported expenditure on most items was substantially higher during the first 3 days. (The effect of pay-day on this finding was eliminated by staggered starting dates.)

The problem of staggered starting dates has been considered at some length here because the requirement of staggering involves extra complexity in the sample design. This will be seen in Section 3.4.2.

3.2.6 Total sample size

In the light of the parameters examined above, we may now consider the total sample size.

The period of continuous recording is generally 1 month, with a few additional days between periods for leave, listing and sampling, introductory visits, etc., making a cyclic period of perhaps 35 days, or say 10 periods in each year.

If the number of households per monthly enumerator's quota is 5, then in a 1-year survey each enumerator covers 50 households. Typically there may be from 15 to 30 enumerators in the long duration type of survey, leading to a sample of 750-1500 household months. If there is one period of continuous recording per household, the number P of distinct quotas per enumerator in the year is 10 and the number of distinct households is 750-1500. If there are two periods for each household, then P = 5 and the number of households is 375-750. Many light-weight surveys and surveys of limited scope have however been based on smaller samples than this.

These figures of total sample size are fixed mainly by the amount of skilled supervision available: there are very few data on sampling errors and in any case variances might well vary widely between different towns so that they can hardly be guessed in advance. Thus in practice most household surveys are simply made as large as can be handled and it is assumed that sampling error will then not be excessive. Probably non-sampling errors have been more important in most surveys.

3.3 Stratification

3.3.1 Geographical stratification with equal sampling fractions

This procedure will be relevant if the survey covers more than one town. Sampling is then normally carried out independently in each town, which means that the towns are strata. In most multi-town surveys this is a practical necessity and in any case it leads to some increase in sampling efficiency.

3.3.2 Stratification with unequal sampling fractions

As in the rural sector (see Section 2.3.2), sampling efficiency requires, for most survey objectives, a higher sampling fraction among the wealthier households. While this requirement may be ignored for the light-weight type of survey, stratification with unequal sampling fractions has been employed in nearly all heavy-weight surveys.

The higher income strata should cover a smaller fraction of the population and should be given a higher sampling fraction. Some *ad hoc* rules for creation of strata and choice of sampling fractions have been suggested in Section 2.3.2 and these apply equally to the urban sector.

As regards the basis of stratification, three distinct methods have been used in African urban surveys, which are described below.

3.3.2.1 Area stratification. In some towns the population has already stratified itself geographically by socio-economic characteristics, so that in any one district of the town income levels are fairly homogeneous. This makes it possible to define approximate income strata on an area basis before any field-work begins, which simplifies the sample design considerably. The method has been used in Yaoundé and Gaberones.

3.3.2.2 Stratification on the basis of housing. In some surveys the ultimate sampling unit has been a unit of housing - called here for the sake of convenience the dwelling (see Section 3.1.2). In such a case, all households in the selected sample of dwellings are surveyed. This technique is only used where a natural unit of housing exists which approximates to the household. Since dwellings are both more easily identified and more stable than the household, they make more convenient sampling units (see Section 3.1.3). The method was used in Yaoundé (1964-5), Brazzaville (1965-6) and Libreville (1967-8). With such a design it is not possible to stratify households as such and stratification is therefore based on the dwelling (unless area stratification is possible, as in Yaoundé). Occasionally this might be possible by reference to some characteristic of the dwelling, but normally one would stratify according to the characteristics of the principal household in the dwelling, using the methods described in Section 3.3.2.3 below. In effect this is household stratification, except that any subsidiary households in each dwelling are automatically put in the same stratum as the main household. This leads to slight inefficiency of stratification, but as long as the average number of households per dwelling is only a little greater than 1 the error will not be serious. If it were much greater - say approaching 2 - the procedure of surveying every household in the sample dwellings would be in any case inappropriate.[1/]

1/ The main object of stratification is to sample a high fraction of wealthy households. This aim is not compromised by the method described. The only anomaly is the over-sampling of poor households, and this matters less.

3.3.2.3 Stratification of households. Since the household is the unit of inquiry, this is of course the most efficient mode of stratification. The reasons why it is not always used have been made clear in Section 3.1.3. The appropriate basis for stratification is best decided by a statistician with local knowledge. Wage-earners can be stratified by approximate income quite easily once their occupation is known. Traders present more difficulty and it is here that local knowledge will be useful in suggesting a basis for separating the wealthier traders from the rest. Unskilled workers and unemployed may generally be grouped in one large stratum.

In both dwelling and household stratification, the information for stratification will normally come from a listing operation in the field, generally the operation by which the sampling frame of dwellings or households is drawn up. In a few exceptional cases, however, an independent source of stratifying information may be available. Thus in Tananarive (1968) households were stratified on the basis of information from a tax-list - even though this list was not found suitable as a sampling frame.

3.4 Sample design

We are now in a position to specify detailed sample designs. We shall assume that a quota of approximately 5 households is to be allocated to each enumerator for a period of approximately one month.

Four requirements may be regarded as essential for any acceptable plan.

A) The households of any one quota must not be too dispersed. This requirement has been defined in more detail in Section 3.1.1 (i).

B) The number of households per quota should bo approximately constant. If it is considered that one enumerator can handle a quota of 5, then quotas of 4 or 6 would be acceptable, but we should try to avoid 3 or 7.

C) Any household sampling frame should be drawn up within a few months of its use for sampling. In view of the high mobility of African households the number of sample replacements necessary would become unacceptable if a household sampling frame more than a few months old were used.

D) The sample should be self-weighting, at least within strata. The larger number of variables analyzed in an urban household survey would make data processing for a non-self-weighting sample excessively cumbersome.

Three further requirements have been mentioned which may or may not be considered necessary, depending on the objectives of the survey and the way in which field work is organized. These are the following:

E) Stratification by income level with unequal sampling fractions in the strata. Generally this will be necessary for any heavy-weight survey and for any survey covering the whole urban population.

F) Long total duration of the survey. This has been discussed in detail in Section 3.2.1.

G) Staggered starting dates for different enumerators. This requirement has been examined in Section 3.2.5.

We first consider, in the light of the above requirements, the question of the grouping of sample households to make convenient enumerators' quotas, then the special difficulty created by the staggered starting dates requirement. We then describe some specific sample designs, showing how they meet the various requirements.

3.4.1 Grouping of sample households

In deciding whether an initial area-sampling stage is required, or more generally whether any concentration of the sample household is necessary in allocating quotas to months, the fundamental question to be asked is the following:

> If the whole household sample were spread evenly over the whole domain of the survey, and groups of 5 neighbouring sample households were made up to form enumerators' quotas, would each quota be sufficiently concentrated in space or would it be too dispersed to be acceptable?

The relevant factors for answering this question are detailed in Section 3.1.1 (i), where we suggest that the limit would generally be reached for a town of population about 50 000. We shall call this limit L. In a town of population greater than L some degree of sample clustering is desirable to prevent the households of one quota becoming too dispersed.

Suppose first that we are below the limit L.

If the survey lasts for only 1 month, then there can be no problem. We simply group the household sample, after selection, into quotas of 5. Note however (Section 3.1.1 (ii)) that an area-sampling stage may sometimes be introduced, even when we are below the limit L, simply to reduce the work at the listing stage. This has no effect on the present argument. It will still be acceptable to group the sample, after selection, into quotas of 5. A given quota will then not always fall within a single sample area, but even so the dispersion of households within a quota will on the average be no greater than before.

If the survey lasts for 3 or 4 months, the quotas have to be allocated to months. This should be done randomly or systematically so that each month's sample is adequately representative of the whole town.

If the survey is to last for longer than this a new problem arises owing to requirement C, the need to renew the household sampling frame every few months. This means that in some way the town will have to be divided up and allocated to months before household sampling begins, but at the same time the areas allocated must still correspond to sample quotas of the desired number of households.[1] The question then has to be asked whether we can identify areas each of which is going to contain the desired quota of sample households. If there is no stratification with unequal sampling fractions, then this will be possible in so far as we can estimate the number of households in each area in advance of sampling. Where this can be done, we may either make up areas containing approximately equal numbers of households and sample with fixed probabilities at the 1st and 2nd stages, or we may sample with PPS at the 1st stage and the reciprocal of this probability at the 2nd. Either will give an approximately constant quota of sample households in each area. The same will apply if there is to be stratification with unequal sampling fractions at the area-sampling stage. Difficulty only arises if we require stratification with unequal sampling fractions at the dwelling or household stage and if the information for this is not available at the time of allocating areas to months. In this case the unequal stratum composition of the areas will lead to unequal samples being selected in the areas.

In this latter case it is not possible to identify in advance areas suitable as 1st stage sampling units, such that they will each contain the desired quota of households in the sample. Instead, therefore, we now require that it should be to some degree possible to have enumerators working in more than one area, so that they can share out the load more evenly. If areas are allocated to months randomly, or systematically at fixed intervals, the distance between two sample areas in any one month will be too great - unless the town is far below the limit L. However, we can achieve the desired flexibility by allocating areas to months in groups of 3 or 4 neighbouring sample areas. If the areas

1/ This difficulty may not arise with the type of sample design in which the dwelling is the ultimate sampling unit, each unit containing an average of only a little over 1 household (see Section 3.1.3). In this case the dwelling sampling frame may be durable enough to last out the whole of a long survey so that the whole dwelling sample may be selected before the household survey begins.

of one group turn out to get a bigger household sample than expected, we can transfer one or more additional enumerators from another group and we can always be sure that no enumerator has more than 6 or less than 4 households. The table below may make this system clearer. It is based on the assumption that areas are allocated to months in groups of 3. The left hand column shows the number of households selected in the sample in the group of 3 areas. The other two columns show how enumerators can be allocated to the group in such a way that no enumerator has more than 6 or less than 4 households.

No. of sample households selected in group of 3 areas	No. of enumerators to be allocated to group	No. of sample households for each enumerator
10	2	5, 5
11	2	5, 6
12	2	6, 6
13	3	5, 4, 4
14	3	5, 5, 4
15	3	5, 5, 5
16	3	5, 5, 6
17	3	5, 6, 6
18	3 or 4	6, 6, 6 or 5, 5, 4, 4
19	4	5, 5, 5, 4
20	4	5, 5, 5, 5
etc.		

The clustering causes a slight inefficiency of sampling. However, if the groups are made to correspond to teams of enumerators, each with one supervisor, the grouping makes supervision easier.

If we suppose, secondly, that the town is larger than the limit L, then an area-sampling stage becomes desirable in order to concentrate the enumerators' quotas. In this case the duration of the survey no

longer affects the problem and the position is similar to the case of the long period survey considered above. Thus, if the number of households per area is known approximately and no stratification with unequal sampling fractions is desired, or only area stratification, then we allocate the selected areas to months systematically so that each month's sample is approximately representative. Otherwise, we allocate them to months in groups or clusters of 3 or 4 to allow more flexibility in making up enumerators' quotas.

We have now covered all possible cases and supplied solutions which meet all the requirements, with one reservation: we have assumed that if one group of 3 or 4 areas receives an excessive number of enumerators' quotas it will be possible to transfer one or more enumerators from another such group. But this will not be possible if enumerators' starting dates are staggered.

3.4.2 Staggered starting dates for enumerators

Staggered starting dates need not create any difficulty within the cluster of 3 or 4 neighbouring sample areas which we are allocating to one month. The necessary small amount of staggering can be easily achieved here by manipulating the enumerators' leave allowance. For example, if we allow 3 days leave per month, and there are 4 enumerators in the group, then the 1st enumerator takes all his leave at the end of the month, the 2nd takes 1 day at the start and 2 at the end, the 3rd takes 2 at the start and 1 at the end, and the 4th takes all 3 at the start. The difficulty is to go beyond this when there are from 5 to 10 teams to be staggered relatively to each other. How can this be achieved without wasting a large amount of their time?

We note also, as shown in the last section, that staggering only creates a problem either if the size of town exceeds L or if the duration of the survey exceeds a few months, and also, in both these cases, only

if household stratification with unequal sampling fractions is required and the data for stratification are not readily available at the time of allocating areas to months.

In these special circumstances the problem arises because, with a self-weighting sample, we cannot prevent the sample of households selected in each area from becoming excessively variable. To deal with this variability we want to transfer enumerators from one group of sample areas to another, but the staggered starting dates make this impossible because enumerators in another group of areas are busy with budget recording during the period when we need them.

There is no radical solution to this, but a number of adjustments can be made which should suffice in practice to give a workable procedure.

The simplest solution is to have a corps of reserve enumerators who can be sent to areas where they are needed. When not fulfilling this function they can work in the office.

Alternatively we can relax somewhat the requirements A and B - that is, allow some enumerators to take on a household outside their area and allow quotas to vary a little more.

If these arrangements are thought unduly wasteful, a more sophisticated solution would be to estimate the weighted size S of each area unit, that is the number of households in the area unit in each stratum weighted by the sampling fraction for that stratum and summed over all strata. The number of households in the strata could be estimated or guessed by any means available. The area units would then be sampled with probability proportional to S, and households ultimately selected with the stated sampling fractions divided by the estimated S for that area unit. In so far as the estimates are good this will reduce the variation in the size of the sample selected in each unit. In practice the remaining variation may well be small enough to be tolerated without any switching of enumerators. This solution was recommended in the ECA plan for the survey of Libreville (1967-8). It

only involved estimating for each area unit the number of dwellings containing a wage-earner with a monthly salary in excess of 30,000 CFA (US $120) and the number without such a wage-earner. This was done in the course of the field operation in which area units were delineated.

Finally a solution which is in some ways more attractive is to complete the whole sampling operation, including the stratification and sampling of households, before the household survey proper begins. Provided we use the method of large area units, equivalent to 3 or 4 quotas, there will then be no difficulty in making up quotas such that all households in any quota come from a single area unit and in allocating the quotas to months in an approximately random manner in such a way that all enumerators are kept fully occupied. The objection to this system is that the household frame will become defective, owing to household mobility, before the end of the survey. However it may be that the resulting error will be within acceptable limits. The best procedure is to survey always the household or households found occupying exactly the living quarters which were occupied by the household selected. In so far as this can be done and in so far as no new accommodation has been constructed, or empty accommodation re-occupied, this will give a correct sample independently of any degree of household mobility.[1/] In some cases it may be difficult to pin-point the exact extent of the accommodation which a household formerly occupied. In others, its mode of occupation may have changed in such a way that it no longer corresponds to an exact number of households. Finally, new construction and re-occupation of formerly empty quarters are not taken into account.

1/ The theoretical justification for this procedure can be seen by regarding the design as a sample of dwellings, where the dwelling is defined as the accommodation occupied by one household in the original frame. Sampling households from the frame is equivalent to sampling such dwellings.

All of these difficulties imply defect in the sampling frame. If such defects are excessive, the method is unacceptable; but it is not easy to forecast whether this will be so in any given case, nor is the problem one that can easily be investigated by a brief pilot survey. Use of the method therefore involves a risk of compromising the success of the survey.

The principle of this method can, of course, be used not merely as a way of solving the problem of staggered starting dates but also in any context in which it is desired to extend the life of a household frame.

The staggering of enumerators' starting dates may at first sight appear to add an undesirable complexity to the survey arrangements. However in reality this complexity is limited to the planning stage. The practical procedure is to make out a chart showing each enumerator's name with his daily programme of work. Each column of the chart corresponds to one day, and the date appears at the head of the column. Each enumerator is given one line. Such a chart shows the supervisor and organizer at a glance where each enumerator is supposed to be on any given day. The individual enumerator is given a copy of the line of the chart relating to him, and from his point of view there is no more complexity than if enumerators were working in unison.

3.4.3 Possible sample designs

The main sample designs meeting the requirements are listed below.

S1 Single-stage sample of households. A frame for this is rarely available (though the method was used in Addis Ababa in 1962-3). If the frame comes from a census or another survey, it must be used rapidly because of household mobility. The household survey would be limited to a few months duration. Stratifying information might be available from the frame. Size of town should be less than E.

S2 Single-stage sample of dwellings with complete coverage of all households in the sample dwellings. Would only be appropriate if number of households per dwelling is not much greater than 1. Municipal register as sampling frame is unlikely to satisfy this condition or to provide stratifying information. Census or survey is a more likely sampling frame. Size of town should be less than L.

S2.1 A useful variant of the above, where a household sampling frame is available which is not more than a year or two old, is to select households from the frame but, in the event that a household has moved, to survey the household(s) occupying exactly the living quarters which were occupied by the selected household. This may be regarded theoretically as a dwelling sample, with the dwellings being defined as the living quarters of one household at the time when the frame was drawn up. This procedure greatly prolongs the life of a household sampling frame but has serious limitations which are described in Section 3.4.2. Stratification may be based on the original household in each dwelling, if suitable information is available from the frame. The method was used in Madagascar (1961-2).

S3 Two-stage sample: dwellings/households. Select sample of dwellings with equal probability. Enumerate all households in the sample dwellings, collecting stratifying information. Then sample households. Method is suitable for any size of dwellings, any duration of survey. Dwelling frame is required. Size of town should be less than L. This is a very widely used sample design.

S4 Two-phase sample of dwellings with complete coverage of all households in dwellings selected at 2nd phase.[1] Select 1st-phase sample of dwellings from a dwelling frame with equal probability. Visit sample dwellings to collect information for stratifying dwellings (unless this information is already available from frame). Stratify and sample the dwellings. Survey all households in this sample. Method requires dwelling frame and is suitable only if number of households per dwelling is not much greater than 1. Size of town should be less than L. Method used in Brazzaville, 1965-6.

S5 Two-stage sample: blocks/households. Same as S1 but with initial block-sampling stage added (see note below).

S6.1 Two-stage sample: blocks/dwellings.[1] Same as S2 but with initial block-sampling stage added (see note). Stratification at block-sampling stage. Advantage: 1 enumerator per block at all stages, with each enumerator able to work to an independent time-table. Method used in Yaoundé, 1964-5.

S6.2 As above but with stratification at dwelling-sampling stage. Used in Freetown, 1966-7; Libreville, 1967-8.

S7 Three-stage sample: blocks/dwellings/households. Same as S3 but with initial block-sampling stage added (see note). Suitable for any size of dwellings, any duration, any size of town.

S8 Two-stage two-phase sample: blocks/dwellings/dwellings.[1] Same as S4 but with initial block-sampling stage added. Requires a dwelling frame with dwellings not much bigger than households, and blocks are created in this frame. (If dwelling frame had to be made in a field operation, S6 would be used instead.) Suitable for any duration, any size of town.

1/ It is assumed throughout this paper that where this method is used the quota per enumerator will be 5 dwellings, but if this is thought unrealistic the necessary modifications can be made by the reader.

Some minor variants of the above have also been used. Much the most popular procedure is S3, but this requires the existence of a dwelling frame. If such a frame has to be made, the obvious way to modify this method would be S7; however, if we make our own dwelling frame we can (in most towns) choose a unit close to a household in size and it then becomes simpler to use S6 (.1 if there is a natural geographical stratification of the population, .2 otherwise).

Note on blocks

Blocks, or area units, should if possible be of the size appropriate to one enumerator's quota, or to 3 or 4 quotas if the method of grouping areas is desired (the conditions for this are explained in Section 3.4.1). If a dwelling or household frame is available the blocks may be made from it. Otherwise one may use census area units, aerial photographs, or maps, for delineating blocks. If there is not full flexibility in allocating enumerators, then either blocks should be of fixed size and sampled with equal probability, or if they must vary in size they should be sampled with PPS. The 2nd stage sampling fraction should then be proportional to the reciprocal of the 1st, to ensure self-weighting.

3.5 Nutrition surveys

Nutrition surveys, in the strict sense in which the enumerator follows a single household and measures all the food that it consumes, are hardly practicable in urban areas as different members of the household may well eat meals (particularly mid-day meals) in different places. Assuming, however, that this problem can be met by substituting questioning for measurement, what would be an appropriate design if one enumerator is to survey no more than one household on any day?

Clearly in this case grouping of the sample presents no advantage and any self-weighting sampling method will be satisfactory. The choice will depend mainly on the availability of a sampling frame. If a dwelling frame is available, method S3 would generally be suitable. Otherwise, S7 might be the most convenient. Self-weighting is achieved by using a 2nd stage sampling fraction which is proportional to the reciprocal of the 1st stage sampling fraction. It does not matter if two households are selected in the same block: they can be handled by two enumerators, or by one enumerator at different periods.

3.6 Sample design for urban household surveys: summary

The following decisions regarding the objectives and organization of the survey must first be taken.

D1 Heavy-weight or light-weight survey. The latter is primarily for determination of weights for a consumer price index. It requires a smaller sample, shorter duration and less stringent standards in data collection. (Section 3.2.)

D2 Number of enumerators = E.

D3 Duration of survey. For light-weight surveys, typically 3 months. For heavy-weight surveys, typically 1 year. Duration also depends on availability of field staff and high level supervision. (Section 3.2.1.)

D4 Length of period of continuous recording in each sample household. Typically 1 month. May be reduced to 1 or 2 weeks for light-weight survey or for non-wage-earners in a heavy-weight survey. (Section 3.2.2.)

D5 Repeat periods of continuous recording in same sample of households. This and D3 determine P, the number of distinct household quotas per enumerator over the whole survey period. (Section 3.2.4.)

D6 Number of households per enumerator's quota = Q. Normally 5, with a tolerance of $\pm$ 1. Total sample of households in the survey may now be computed = E x P x Q. (Section 3.2.6.)

D7 Is income stratification of households required with unequal sampling fractions? Generally yes, even for a light-weight survey. (Section 3.3.2.)

Secondly, the availability of sampling frames has to be considered. Is a household or dwelling frame available? If the latter, are the dwellings approximately the size of households or are they much bigger? (A unit such that households are often split between two dwellings would not be acceptable.) If these frames are not available, can area units be delineated from census records, aerial photographs or maps, and can the approximate number of households in each area unit be estimated?

Thirdly, certain characteristics of the town have to be considered. Is the town larger or smaller than the limit L, defined in Section 3.4.1? Is the population naturally stratified, so that stratification of the sample by income level (if desired) can be achieved by means of area stratification?

A choice can now be made between the sample designs listed in Section 3.4.3. The considerations affecting the choice are listed below.

Sampling frames and sampling units

1. If a household frame is available, this can be used as such for a few months from the date when it was drawn up, after which it will be out of date. (Designs S1, S5.)

   In some cases the life of a household frame can be prolonged to a year or two by the method of S2.1: surveying the household(s) currently occupying exactly the same living quarters as the household selected. But it is difficult to predict in any given case how well this will work and there is a risk of compromising the soundness of the sample design. (See section 3.4.2.)

2. If a dwelling frame is available but no household frame, and if the dwellings each contain at least 1 household and no more than 1.5 households on the average, then the best sample design will generally be to cover all households found in the selected dwellings at the time of interview. (Designs S2, S4, S6, S8.) (See Section 3.1.3.)

3. If only a dwelling frame is available, with each dwelling containing many households, or a widely varying number of households, then a further sampling stage is desirable, namely sampling of households within selected dwellings. This requires a field operation for listing of all households in the sample dwellings. (Designs S3, S7.)

4. If neither a household frame nor a dwelling frame is available, then one must be created by a field listing operation, either over the whole town or within a sample of areas (see 5 below). In most cases a dwelling frame will be preferable at this stage, rather than a household frame, dwellings being more rapidly identified and more stable. It will often be possible to use for the listing unit a definition of dwelling that approximates to a single household, and we then return to case 2 above (S6) within the selected area units. If only larger units of housing can be listed (e.g. house numbers), we go to case 3 above (S7). If, exceptionally, households are listed at this stage, we go to case 1 (S5).

Area-sampling

5. A stage of area-sampling is necessary in the following circumstances (see Section 3.4.1):

   5.1 When the town population exceeds L, in order to group or concentrate the enumerators' quotas.

   5.2 When the town population is less than L, and no dwelling or household frame is available and it is considered that the work of creating such a frame by listing the whole town would be excessive.

6. When area units or blocks are required for sampling, either these may be made up in the dwelling or household sampling frame, if such exists, or they may be delineated from aerial photographs or maps, or use may be made of existing census or administrative areas.

7. It is a convenience if area units can be made up in such a way that the number of households to be selected in each is appropriate for one enumerator's quota, say 4 – 6 households. This condition is compatible with self-weighting only if the number of households in each area unit is known at the time of selecting the area sample. Moreover we need to know the number in each stratum in each area unit, if stratification with unequal probabilities at the dwelling or household stage is desired. (See Section 3.4.1. Also Section 2.4.4.) This knowledge will normally be available in any one of the following circumstances:

   i) If a household sampling frame covering the whole town is available, or if it is feasible to make one. If stratification is required, then the stratifying information must be available from the frame.

   ii) Similarly for a dwelling frame, provided the dwellings are approximately equal to households.

   iii) If there is to be no stratification, or only stratification at the area-sampling stage, and if the number of households in each area unit can be estimated to within ± 20%. Such an estimate might be feasible from a census, or a count of buildings or lots seen in aerial photographs or maps supported by census or survey data on density of occupation in different districts.

When these conditions are fulfilled, either of two sampling methods may the be used:

7.1 Make up area units of equal size.[1] Sample with fixed probability at 1st and 2nd stages.

7.2 Make up area units of variable size.[1] Sample with PPS at 1st stage and the reciprocal of this at 2nd stage. This is generally preferable as it allows flexibility in delineating area units, so that natural boundaries can be used.

In both cases, choose the constant of the 2nd stage sampling fraction so that the number of households to be selected will average 5 in each area unit.

8. If the population of the town is below the limit L, then even when an area sampling stage is used the requirement of 7 above (1 quota per area) is not crucial: an enumerator can take over a household in a neighbouring sample area without inconvenience. In this case therefore the methods of 7 above still apply, the only difference being that the estimates of "size" will be less accurate. (See Section 3.4.1.)

1/ If stratification is required with unequal sampling fractions f_h in the strata h, then the "size" should be the number N_h of households in the area unit in stratum h, weighted by f_h and summed over h. I.e. size = $\sum N_h f_h$. If such stratification is not required, size = number of households in the area unit. (See Section 2.4.4.)

9. If the population of the town exceeds L, then allocation of households to quotas is not fully flexible. If area units are required for sampling but it is impossible to obtain units of known size, then make up units, before sampling, which are estimated to be 3(or 4) times the size that would yield a single enumerator's quota.[1/] One can then be sure that the sample households actually selected in each area can be made up into a whole number of quotas, with no quota being more than 6 or less than 4. (See Section 3.4.1.)

Allocation of households to quotas and quotas to months

10. If area-sampling not used:

10.1 Sample designs S1 and S2. Select the sample of dwellings or households before the household survey begins. Group the sample into quotas. Allocate quotas to months.

10.2 Sample designs S3 and S4. Select 1st-stage (or phase) sample of dwellings before household survey begins. Make up groups of sample dwellings, each group expected to yield a sample of 3 (or 4) quotas. Allocate these groups to months. Select 2nd-stage (or phase) sample at beginning of each month. Make up quotas of 4 – 6 dwellings or households, no quota to have households from more than one group.

Note. In a survey of short duration, and possibly one of long duration when S4 is used, it might be preferred to complete both stages (or phases) of sampling before the household survey begins. In this case use the method of 10.1.

1/ This number, 3 or 4, may conveniently be chosen equal to the number of enumerators in the average supervisor's team. This will concentrate the team and assist supervision.

11. Area-sampling used:

11.1 Case 7 above. Select area units. Allocate units to months. The sample in each area unit constitutes one quota.

11.2 Case 8 above. Select area units. Make groups of 3 (or 4) sample area units. Allocate such groups to months. Group the selected dwellings or households into a whole number of quotas within each group of area units.

11.3 Case 9 above. Select large area units (as indicated in 9). Allocate these to months. Group the selected dwellings or households into a whole number of quotas within each area unit.

Note. In all cases, the stated units should be allocated to the survey months randomly or systematically, so that each month's sample is approximately representative of the whole survey domain. The term "month" is used for simplicity: more strictly this should be cycle - in most cases rather more than one month.

12. The requirement of staggered starting dates (see Section 3.4.2) would cause difficulty in all cases where it has been recommended to group 3 or 4 quotas or areas together. These are the cases in which the number of quotas is not known in advance, so that it may be found desirable to transfer enumerators. Staggered starting dates impede such transfers. Methods of overcoming this difficulty are described in Section 3.4.2.

Income stratification

13. In choosing the basis for income stratification, note that the earlier the sampling stage at which stratification is introduced the simpler the sampling arrangements, while on the other hand the less less precise is the stratification. Thus, area stratification simplifies the sampling but is least efficient; household stratification causes the most trouble but is the most efficient; dwelling stratification is intermediate. The choice will depend on factors already discussed and on a judgment, for the particular town concerned, of whether the loss of stratifying efficiency would be acceptable if stratification at an earlier stage were introduced. (See Section 3.3 for further details and Section 2.3.2 for some suggested rules for forming strata and choosing sampling fractions.)

Nutrition surveys

14. See Section 3.5.