

# **THE ROYAL STATISTICAL SOCIETY**

## **2009 EXAMINATIONS – SOLUTIONS**

### **ORDINARY CERTIFICATE**

#### **PAPER I**

The Society provides these solutions to assist candidates preparing for the examinations in future years and for the information of any other persons using the examinations.

The solutions should NOT be seen as "model answers". Rather, they have been written out in considerable detail and are intended as learning aids.

Users of the solutions should always be aware that in many cases there are valid alternative methods. Also, in the many cases where discussion is called for, there may be other valid points that could be made.

While every care has been taken with the preparation of these solutions, the Society will not be responsible for any errors or omissions.

The Society will not enter into any correspondence in respect of these solutions.

Ordinary Certificate, Paper I, 2009. Question 1

- (i) Several methods are possible. For example:

Could take a random sample of regions at the first stage, each region being a cluster of administrative districts (cluster sampling). Could take a simple random sample of districts in selected regions at the second stage and then contact all adults listed in these districts (no further sampling). Note: the districts can be considered to be clusters of adults so this could be argued to be two-stage cluster sampling.

Consider the administrative districts as lying in strata classified as urban and rural, possibly also with regions as strata. As the first stage of sampling take a simple random sample of districts from each stratum (stratified sampling). At the second stage of sampling take systematic samples of adults from the lists in the districts in the sample.

- (ii) Comments on benefits and drawbacks may depend to some extent on the sampling designs suggested in part (i), but are likely to include the following.

Cluster sampling benefits: administratively easier than other methods; less travel if interviewers are used. Cluster sampling drawbacks: districts within a cluster might be similar to one another; clusters chosen might be atypical of districts in the country as a whole; estimators are complicated.

Simple random sampling benefits: estimation is easy; properties of estimators are well understood. Drawbacks: moderately complicated to select a sample; extreme/atypical samples might occur.

Stratified sampling benefits: ensures both rural and urban districts (and all regions if used as strata) are represented in the survey. Drawbacks: involves stratifying districts as a first step; can lead to reduced precision if the stratification is poorly done.

Systematic sampling benefits: easy to implement; ensures good representation of adults by address. Drawbacks: might not behave as a simple random sample if there are cycles in the lists; cannot estimate variability.

- (iii) To obtain a sample of all adults would need supplementation of the sample of adults in private households by sampling adults living in institutions such as hostels, residential homes and prisons. Care would be needed to ensure there was no duplication, for example somebody listed as in a private household six months ago might now be in prison. Obtaining access to suitable lists might be difficult due to confidentiality.

Ordinary Certificate, Paper I, 2009. Question 2  
**(Solution continues on next page)**

Instructions to interviewers for the start of the interview may be as follows. Other instructions are inserted in the questionnaire.

When you get a reply from the address at which you have been asked to call, show your identity card and say the following: "Good morning (or afternoon, evening, as appropriate). I work for XXX and have been asked to interview ABC whose address I believe this is. Is ABC in?" If the answer is "No", try to find out when ABC might be in and arrange to call back. If the answer is "Yes", ask to see this person unless you are already speaking with him/her.

When speaking with ABC, or if asked by the person answering the door, say "As you probably know" (or if person is not ABC "might know") "from a letter that you have (or ABC has) been sent, the government is interested in finding out adults' perceptions of crime and has asked my organisation to undertake a survey on this topic. You have (or ABC has) been selected by a random process as a person who could help, and we would be very grateful if you (or ABC) would answer some questions. This will take at most half an hour."

If ABC agrees, say "Thank you" and then start asking the questions below in order and record the answers, ticking boxes where appropriate. If ABC refuses, apologise for taking his/her time and try to arrange an alternative time of interview.

Q1. Do you think that crime is a problem in your neighbourhood?

Yes	No	Don't know	Did not answer
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Q2. Compared with five years ago, do you think the level of crime in your neighbourhood is now

Lower?	
About the same?	
Higher?	
Don't know or did not answer	

Q3. Compared with five years ago, do you think the level of crime in the country as a whole is now

Lower?	
About the same?	
Higher?	
Don't know or did not answer	

Q4. Do you think that violent crimes are on the increase in the country as a whole?

Yes	No	Don't know	Did not answer
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Q5. Violent crimes are sometimes committed by those aged under 16 years of age. What are your feelings about this?

[Interviewer: record verbatim as far as possible.]

Interviewer: now say "To put your replies in context, I am now going to ask you some questions about yourself. It will not be possible to identify you in any way from the published results of the survey which will be as tables."

Q6. Are you

Married or in a civil partnership?	
Divorced or separated?	
Living with a partner?	
Single and not living with a partner?	

Q7. What is your occupation? .....

Q8. What is your age group? (Interviewer: show card and record answer.)

18 – 24	
25 – 44	
45 – 64	
65 – 79	
80 and over	

Interviewer, now say the following: "That is the end of the questions. Thank you very much for taking the time to answer them. Is there anything you would like to ask me or anything else that you would like to add?" Record responses. Answer any questions if you are able to do so, or say you will try to find out the answers and that someone will get back to the interviewee. Record the action. Record anything interviewee adds.

Record the sex of the respondent. This is a check as the name of ABC will usually reveal this.

Male	Female	Not clear
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Return completed forms to the office as requested.

Ordinary Certificate, Paper I, 2009. Question 3

As the topic is a sensitive one, self-completion questionnaires (no interviewer present) are more likely to elicit honest responses than telephone interviews. The respondent would have time to reflect on the answers and to remember details that might have been suppressed. The questionnaire could use closed questions and examples to prompt the respondent's memory and ensure that the respondent knew what kinds of incidents constituted crimes. In addition, not everyone will have a telephone; in a telephone call it could be difficult for the interviewer to establish rapport with the respondent; identification details cannot be shown; more concentration is needed in a telephone interview and respondents are likely to become tired if the interview is long; it is not easy for the respondent to look up facts; there could be background noise and/or the chance of others overhearing the interview.

Advantages of telephone interviews compared with self-completion questionnaires are that people often keep the same telephone number when they move house; the researcher will know quickly whether or not the selected sample member is willing to respond, so there is no time and money spent on following up non-respondents; and it is usually possible to get a reply from a telephone number even if an answer-phone.

Ordinary Certificate, Paper I, 2009. Question 4

(i) Advantages of quota sampling over simple random sampling.

It does not require a sampling frame, so it is useful when no suitable frame exists.

It is quick to do as interviewers are not constrained to find named respondents, so there are no call-backs.

Hardly any preparatory work in the office is required.

Controls, such as limiting the numbers of men and of women to interview, are relatively easy to use.

The costs of planning and analysis are less than in random methods with call-backs.

A target sample size can usually be achieved.

(ii) Disadvantages of quota sampling compared with random sampling.

There is no theoretical method of assessing sampling variability (but there are methods of estimating variances).

Control of fieldwork is more difficult than in random methods. Undetected errors are a hidden cost.

Interviewers could be biased in their choice of sample members. For example, they might select people of a similar type to one another.

Interviewers might misclassify people in order to fill their quotas (or, indeed, accidentally).

Some groups might have no chance of being chosen (depending on when and where the fieldwork is done).

Refusal rates tend to be higher than in random methods, and this might introduce substantial bias.

Ordinary Certificate, Paper I, 2009. Question 5

- (i) The sampling fraction is  $150/750 = 1/5$ .

For "budget",  $377/5 = 75.4$ ; for "standard",  $303/5 = 60.6$ ; for "de luxe",  $70/5 = 14$ .

This suggests taking sample sizes of 75, 61 and 14 from those who have booked budget, standard and de luxe cabins respectively.

(ii)	$N_h$	$S_h$	$N_h \times S_h$	$N_h \times S_h / \Sigma(N_h \times S_h)$	$\{N_h \times S_h / \Sigma(N_h \times S_h)\} \times 150$
	377	8850	3336450	0.4387	65.8
	303	13005	3940515	0.5181	77.7
	<u>70</u>	4695	<u>328650</u>	0.0432	6.4
	<u>750</u>		<u>7605615</u>		

This suggests taking sample sizes of 66, 78 and 6 from those who have booked budget, standard and de luxe cabins respectively.

- (iii) The sample size from those who have booked de luxe cabins is very small, particularly in the method of part (ii). If there is high non-response from this group, the achieved sample size could be negligible, leading to poor representation of this group and high standard errors.

The method of part (ii) depends on standard deviations found from a past survey and from a different group (those booking with this travel firm are not necessarily similar to a wider population of those who go on cruises, many of whom might not have booked with this firm). If these standard deviations are very different from those for the group in question, then the sample sizes of (ii) will not be optimal for estimation of the mean annual income of those who booked with this firm.

Ordinary Certificate, Paper I, 2009. Question 6

The main sources of error in an interviewer survey of a random sample of cruise passengers drawn from passenger lists are sampling error, measurement error, non-response, interviewer effects and processing errors.

Sampling error occurs because only a sample of passengers is selected. If the method is random there would be no sampling biases, but this does depend on having a good sampling frame. If there are problems with the frame such as duplication of names or omissions of names then sampling biases will occur.

Measurement error might be due to problems with the questionnaire, for example if a question is worded in such a way that it measures something different from what was intended. Respondents do not necessarily give true answers to questions, either deliberately or because they do not know or have forgotten details. However, if the responses resemble the truth, measurement error from this source will be small. Measurement error also occurs when interviewers record responses incorrectly. This might be because they did not hear a response properly, but might also be a transcription error, or even deliberate. Measurement error can also occur during processing.

Non-response would occur if the passenger refuses to be interviewed or is unavailable for interview. Partial non-response would occur if the response was missing on some questions. Views of non-respondents might differ markedly from those of respondents and, unless other information was available, there would be no way of knowing whether this was the case.

Interviewer bias is when an interviewer influences the response in some way. This might occur because of the relationship between the interviewer and respondent, or because of the way the interviewer asks the questions, or interprets the responses. The general looks and demeanour of the interviewer can also have an effect.

Processing errors occur if a wrong estimation method is used, in particular if inappropriate weights are used. Incorrect entry of responses into a database might also be regarded as a processing error.

Ordinary Certificate, Paper I, 2009. Question 7

In a question in open format (often referred to as an open-ended question), the respondent is given no suggestions of possible answers. In questions in closed format, alternative responses are given. In a closed question with a single answer, the alternatives are mutually exclusive and the respondent is asked to choose one. In a closed question with multiple answers, the respondent is asked to choose as many as apply. Sometimes an "Other, please state" option is given in a closed question.

An example of an open-ended question is "How many cruises have you gone on previously?"

An example of a closed question with multiple answers is

"Which of the following newspapers do you read at least once a week? Please select as many as apply."

The Daily Telegraph	
The Guardian	
The Independent	
The Daily Mirror	
The Sun	
Other – please specify	

An example of a closed form question with a single answer is

"Do you hope to go on another cruise within the next two years?"

Yes	
No	
Don't know	

Ordinary Certificate, Paper I, 2009. Question 8

- (i) The amount of money taken each month is known as the value and is equal to price per item times number of items sold. Clearly data suitable for monitoring changes in the value per month would consist of prices and quantities sold of a sample of the different magazines and newspapers. The quantities could be obtained from records of stock coming in and subtracting the amounts unsold and ultimately removed from sale.

Decisions would need to be made as to which publications and which outlets to include. A decision would also be needed as to the definition of a month, as calendar months vary in length. A decision is also needed as to when to collect the prices as there might be variations throughout the month; for example, there might be reductions in prices of out of date publications. Further, a decision is needed as to when to collect quantities. The last day of each month might be suitable.

- (ii) A simple way to summarise the information is to estimate a total value or an average, or alternatively to form an index relating the value each month to the value at a fixed point in time. All of these summaries [only one was required from candidates in the examination] involve summing over a number of different magazines and newspapers.

To update the summary, prices and quantities would need to be collected every month and in a similar way as was done initially. However, changes of buying habits and of what is published might need to be considered (in other words, the "basket" of goods might need to be changed if the monitoring took place over a long period of time).

- (iii) Many sampling schemes are possible. As it is a chain of newsagents, taking a sample of outlets, perhaps stratified by area of the country, might be sensible; though as prices of magazines and newspapers tend to be fixed, a relatively small sample should suffice. What will vary is the publications stocked in different outlets, for example one in a business district is more likely to stock the Financial Times and less likely to stock Playboy.

Sampling of newspapers and magazines is desirable. These might be stratified by type; for example, magazines might be put into such groups as women's, professional, gardening and so on. Stratification by frequency and time of publication is also needed, probably as daily, weekly and monthly. Simple random samples from the different strata could be taken. An element of purposive sampling might also be done if, say, some publications tended to be price leaders.