Analytical Support for Decision Making
Individual Assignment 2021-22

Preamble

This assignment accounts for 100% of the overall mark for the ASDM Class.

The aims of the assignment are to engender a good understanding of, and skills in, the following aspects of the ASDM class:

- Using a spreadsheet to make sense of data;
- Conducting and interpreting statistical analyses on a data set of reasonable size;
- Using appropriate analysis techniques to structure and inform a decision.
- Presenting your analyses in visual and written form;

The report for this assignment should have three parts. The division of marks and a page length guide for the three parts is summarised below. All parts are compulsory, and each part focuses on a different set of skills. For Part 2 and Part 3 there are multiple problems, and students should answer only one problem from the available options. Students will not receive an overall mark unless a credible attempt is submitted for each part. If students submit answers to multiple problems from parts 2 or 3, only the first problem answered in each case will be marked.

The overall report length must not exceed 8 pages, including appendices. Each part has a strict page limit (detailed below), which should comprise of two sections:

- **A summary section**: this is expected to be brief and concise, and be targeted at a senior manager whose knowledge of statistics and analysis is very limited. It should clearly identify the problem you have tackled, describe the approach you have taken to address the problem, identify any issues or limitations in your analysis, and provide any concluding recommendations that directly address the problem. Note that figures may be included in the summary if these help to communicate your findings, however, it is expected that most figures will be presented in the appendix section.
- **A technical appendix section**: this should provide all evidence that is necessary to support your summary, and to provide confidence that you have taken a robust approach to the problem. This should include appropriate levels of detail on the approach that you have taken, and show any charts, diagrams, and tables that support your summary. Any assumptions you have made with your analysis should be clearly stated and justified as appropriate. Any modelling decisions you have made should be justified as appropriate.

	Description	Marks	Page Guide
Part 1	Technical Report on Exploratory Analysis	40	3 pages including: one summary section, and one technical appendix section with any charts, diagrams, tables
Part 2	Technical Report on Statistical Analysis Methods	30	2 pages including: one summary section, and one technical appendix section with any charts, diagrams, tables
Part 3	Technical report on Decision Analysis Methods	30	3 pages including: one summary section, and one technical appendix section with any charts, diagrams, tables

Note: we assume a page to be A4, single-spaced, 11 point characters - i.e. around 300 words.
Each student should submit one report. You should also include where applicable:

- A copy of any Excel files used for your analysis.
- A copy of any VISA files used for your analysis.

Note that the Excel and VISA files will not be marked, but are required to demonstrate that the analysis you report on has actually been conducted.

You will be advised of the deadline for submission of this assignment, and subsequent return of marks, by your MBA Administrator.

A copy of the blank assignment feedback form is available on Myplace so that you have visibility of the marking criteria and marks breakdown.

This assignment has been set by the MBA ASDM Teaching Team 2021-22.

Introduction to the Assignment Context

The Manager of a local hospital has asked for your help. She thinks that the blood transfusion activity at the hospital is in need of improvement, and has identified a number of problems for which she would like some analysis to be conducted. Unfortunately there is no-one in the Department with the necessary skills to conduct the analysis. You have been asked to focus on three problems, and provide a suitable management report to support the Manager's decision making.

Note: the data provided is real and comes from a Scottish hospital but the name of the actual hospital has been kept confidential.

Background to the Problem

As most people are aware, blood and blood products are a key resource for a health service and are used in providing emergency treatment, in surgical treatment (operations) and in routine care. There are 4 main blood groups (known as ABO): A, B, O and AB. In addition, people either have, or do not have, the Rhesus factor on the surface of their red blood cells. This is usually indicated by 'RhD positive' (does have) or 'RhD negative' (does not have) suffix to the ABO blood group. This means that generally there are 8 main blood types. (Note; this is an oversimplification for the purpose of this assignment. There are in fact over 30 different blood types). Table 1 shows the 8 main blood types and the percentage of the UK population in each blood type category. Table 2 shows a number of international comparisons.

Table 1 Blood types and UK population
Source: Blood Transfusion Service website

	Positive	Negative	Total
O	37%	7%	44%
A	35%	7%	42%
B	8%	2%	10%
AB	3%	1%	4%

Table 2 ABO and Rh distribution by country
Source: Wikipedia

ABO and Rh blood type distribution by nation (population averages)								
Country	**O+**	**A+**	**B+**	**AB+**	**O–**	**A–**	**B–**	**AB–**
Australia	40%	31%	8%	2%	9%	7%	2%	1%
Austria[1]	30%	33%	12%	6%	7%	8%	3%	1%
Belgium	38%	34%	8.5%	4.1%	7%	6%	1.5%	0.8%
Brazil	36%	34%	8%	2.5%	9%	8%	2%	0.5%
Canada	39%	36%	7.6%	2.5%	7%	6%	1.4%	0.5%
Denmark	35%	37%	8%	4%	6%	7%	2%	1%
Estonia	30%	31%	20%	6%	4.5%	4.5%	3%	1%
Finland	27%	38%	15%	7%	4%	6%	2%	1%
France	36%	37%	9%	3%	6%	7%	1%	1%
Germany	35%	37%	9%	4%	6%	6%	2%	1%
Hong Kong SAR	40%	26%	27%	7%	0.31%	0.19%	0.14%	0.05%
Iceland	47.6%	26.4%	9.3%	1.6%	8.4%	4.6%	1.7%	0.4%
India	36.5%	22.1%	30.9%	6.4%	2.0%	0.8%	1.1%	0.2%
Ireland	47%	26%	9%	2%	8%	5%	2%	1%
Israel	32%	34%	17%	7%	3%	4%	2%	1%
New Zealand	38%	32%	9%	3%	9%	6%	2%	1%
Norway	34%	42.5%	6.8%	3.4%	6%	7.5%	1.2%	0.6%
Poland	31%	32%	15%	7%	6%	6%	2%	1%
Portugal	36.2%	39.8%	6.6%	2.9%	6.0%	6.6%	1.1%	0.5%
Saudi Arabia	48%	24%	17%	4%	4%	2%	1%	0.23%
Sweden	32%	37%	10%	5%	6%	7%	2%	1%
Netherlands	39.5%	35%	6.7%	2.5%	7.5%	7%	1.3%	0.5%
Turkey	29.8%	37.8%	14.2%	7.2%	3.9%	4.7%	1.6%	0.8%
United Kingdom	37%	35%	8%	3%	7%	7%	2%	1%
United States	37.4%	35.7%	8.5%	3.4%	6.6%	6.3%	1.5%	0.6%

Blood Transfusion

Transfusion medicine is a specialized branch of haematology that is concerned with the study of blood groups, along with the work of a blood bank to provide a transfusion service for blood and other blood products. Across the world, blood products must be prescribed by a medical doctor (licensed physician or surgeon) in a similar way as medicines. Much of the routine work of a blood bank involves testing blood from both donors and recipients to ensure that every individual recipient is given blood that is compatible and is as safe as possible. If a unit of incompatible blood is transfused between a donor and recipient, a severe acute haemolytic reaction, renal failure and shock are likely to occur, and death is a possibility.

Patients should ideally receive their own blood or type-specific blood products to minimize the chance of a transfusion reaction. Risks can be further reduced by cross-matching blood, but this step may be omitted when blood is required for an emergency. Cross-matching involves mixing a sample of the recipient's serum with a sample of the donor's red blood cells and checking if the mixture agglutinates, or forms clumps. If agglutination is not obvious by direct vision, blood bank technicians usually check for agglutination with a microscope. If agglutination occurs, that particular donor's blood cannot be transfused to that particular recipient.

Blood Compatibility

Although ideally patients should receive matched blood products, in practice some blood group types are compatible with others. Table 3 shows the compatibility between donor and recipient. So for example, a patient who is A- can be given A- blood (their own type) but also O- blood. In fact, examination of Table 3 indicates that O- blood is compatible with all the other blood types and can be used on all patients. O- blood products are often referred to as “universal” as they can be used for all patients. This can be extremely useful, for example, in emergencies when a blood transfusion is needed urgently and there may not be time to identify the patient’s actual blood type.

Table 3 Red blood cell compatibility table
Source: Wikipedia

Note - Assumes absence of atypical antibodies that would cause an incompatibility between donor and recipient blood, as is usual for blood selected by cross matching.

Recipient[1]	Donor[1]							
	O−	O+	A−	A+	B−	B+	AB−	AB+
O−	✓							
O+	✓	✓						
A−	✓		✓					
A+	✓	✓	✓	✓				
B−	✓				✓			
B+	✓	✓			✓	✓		
AB−	✓		✓		✓		✓	
AB+	✓	✓	✓	✓	✓	✓	✓	✓

Blood Donations

In the UK, for example, blood supplies are generally obtained through a national blood donor service where citizens voluntarily donate blood, usually twice a year. After donation, the blood goes off to specialist laboratories for routine testing. In Scotland there are two testing labs, in Glasgow and Edinburgh, both working round the clock. The following tests are carried out on every donation:

- HIV - All donations are tested for antibodies to the HIV1 and HIV2 viruses which cause AIDS
- Hepatitis viruses - Hepatitis is an inflammation of the liver which may cause jaundice and sometimes liver failure. All donations are tested for hepatitis B and C.
- Syphilis - Syphilis, a sexually transmitted disease, can be passed on through blood, so all donations are tested.

Typically a donation will have been processed and tested and ready for use within 48 hours. Blood has a very short shelf life of around 35 days and has to be stored and distributed under stringent conditions.

Assignment Tasks

As outlined above, for parts 1, 2 and 3 below you should prepare a summary report and a technical appendix. The summary report should be written for the manager whose knowledge of statistics and analysis is very limited. You may use the technical appendices to show any technical analysis that you have conducted (note that appendices are included in your page limit).

For each question you answer, provide your answer along with any supporting evidence. In each case choose which of the methods covered in the class you think are best-suited to each problem, and justify this choice with a sentence or two. Discuss any assumptions, issues, or limitations in your analysis, along with any concluding recommendations.

Part 1: Exploratory analysis (40 marks)
All students should attempt this question

The hospital manager you have been asked to help faces a difficulty. Although O- blood is universal, in the sense that it can be used safely with virtually all patents, it is also in short supply. Table 1 indicates that only around 7% of the UK population is O- and, by implication, only around 7% of blood donations will be O-. The manager would prefer medical staff to be using appropriately matched blood wherever possible and restricting the use of O- blood to those patients who really need it: those patients who are actually O- (since from Table 3 there are no other compatible blood types) and those patients who require emergency blood transfusion (where there is no time to check their blood type).

On the other hand, the manager does not want donated blood to be wasted, which can happen if blood is not used within its shelf life (each unit of blood is marked with an expiry date). As a result, she has carried out some data collection in the hospital over the last six months. A record has been kept of every patient who received O- blood during that period. The following data has been collected on each patient (and is available in the accompanying Excel file for this assignment).

ID: a patient identifier
Gender: Male/Female
Age: of the patient in years
ABO: Blood group of the patient – O, A, B, AB
Rh: POS(itive) or NEG(ative)
Emergency: whether the patient was an emergency admission and so needed an O- transfusion. Y for Yes, otherwise blank
Units: total number of units of blood transfused
Reason: for patients whose blood group was **not** O-, the reason (if known) they were given O- blood.

- X means they were given O- blood because the blood available was close to its expiry date and would otherwise have been thrown away
- N means that the hospital blood bank had no supplies of the patient's actual blood type in stock and so O- blood was used instead
- Z means there was some other medical reason for giving the patient O- blood;

Age of blood: the maximum age (in days) of the blood units used for transfusion. E.g. a 2 unit transfusion with age of blood equal to 15 days means that one unit is 15 days old, and the other is at most 15 days old.
Duration of Stay: the number of days for which the patient remained in hospital after the transfusion.

Note for some patients there is incomplete data and some cells may have been left blank/empty.

Your first task is to conduct a thorough analysis of the data presented and to write a report for the hospital manager summarising the key findings in relation to use of O-blood within the hospital. The manager is interested in acquiring a better understanding of hospital's demand for blood to inform purchasing and storage decisions. Your analysis should include, but not be restricted to, analysis of demand on a daily basis as well as the aggregate demand over a 35 day period which corresponds to shelf life. Your analysis should give a breakdown of the demand where appropriate, but only where this is insightful and with justification provided. Appropriate visualisations should be used to support your analysis.

Part 2: Statistical analysis (30 marks)

Students should select only one of the following questions (choose either question 2.1, 2.2 or 2.3 – note that 2.3 has multiple parts to be answered)

Question 2.1

2.1 Info: The Manager has heard anecdotal evidence that patients who receive older blood (i.e. closer to its expiry date) are more likely to suffer adverse effects from the blood transfusion. She would like to use the Excel data described for Part 1 to determine if there is any evidence of this relationship, which could be used to identify an improved strategy to handling the blood expiry. Specifically, her question is as follows:

2.1 Task: Can the age of blood used in the transfusion be used to predict the duration of a patient's stay? Does this relationship vary between patient blood types?

Question 2.2

2.2 Info: The Manager would like to ensure that more transfusions occur with closer matched blood types, so that the O- blood supplies are less commonly used for non-O- patients. Excess demands of a blood type are assumed to represent demands that exceed supply of the blood type (e.g. if there are 2 units of A+ supplies available, and demand is for 5 units of A+, then there is an excess demand of 3 units which need to be covered using an appropriate substitute for A+). Assume that at present, all excess demands are fully covered by O- blood supplies, and that all transfusions of O- to other blood groups could be avoided if there were sufficient supplies of appropriate alternatives. The Manager is considering a revision to the strategy to handle excess demands, and would like some analysis of the Excel data described for Part 1, to give a better understanding of these (see details below).

2.2 Task: How many additional units of each blood type would be required per 35 day period to ensure that required demands could be satisfied in 99.99% of cases (e.g. how many additional units of O+ blood would remove the excess demands on the O- supplies with a probability of 0.9999)? HINT: carefully consider the role of the Central Limit Theorem in modelling aggregate demand over a 35 day period.

Question 2.3

2.3 Info: The manager would like to use available data to inform decisions on managing the blood transfusion system in the hospital. However, she is unsure about the quality of data that has been collected, and whether this can be used with confidence. In particular, she is unsure whether the Excel data sample described for Part 1 is sufficient data to give a true representation of the hospital's blood use. Additionally, she is unsure whether international approaches to managing blood use can be appropriately transferred to a UK hospital. See parts 2.3(i) and 2.3(ii) below.

Regarding the Excel data described for Part 1, the Manager would like to confirm that the data is actually representative of the hospital's blood use needs. She believes that the O- supplies would be used for other blood types at rates that are equivalent to the distribution of individuals with those other blood types, and would like to check how these rates compare with the national average.

2.3 Task (i): for each blood group (except O-), is the proportion of cases in the Excel data sample different to the national average shown in Table 1 (use an appropriate confidence interval to justify your answer)? Using your answer, advise the manager on her query.

Various studies have been published which describe blood management approaches that have been effectively deployed in different countries around the world. The Manager has identified some approaches that sound applicable in her hospital, but she is unsure whether the data can be assumed to be comparable with the UK data. The Manager is aware that, as blood is inherited from parents, there are genetic differences in blood type distributions between countries, as shown with Table 2. However, the Manager thinks that the differences in Table 2 could just be artefacts of the data collection approach in each country.

2.3 Task (ii): Is the UK proportion of O- cases statistically different to the average proportion of O- cases from the sample of other countries shown in Table 2 (use an appropriate confidence interval to justify your answer)? Using your answer, advise the manager on her query.

Part 3: Decision Analysis (30 marks)

Students should select only one of the following questions (choose either question 3.1, or 3.2)

Part 3 General Info:

As part of a wider improvement initiative, the hospital manager is considering how the hospital's blood bank service can be made more efficient and more effective. At present, the main blood bank, where donated blood is stored, is at a large regional hospital about 80km away. The local hospital has only a small blood bank facility where typically only a few days' supply of blood can be safely stored. The regional hospital routinely supplies blood on an anticipated or forecast basis and these stocks are replenished every few days or, in the event of a stock shortage at the local hospital, can be shipped through at a few hours notice (although at considerable cost). The hospital manager is reviewing a number of options and has heard (vaguely) about the use of multi-criteria methods. She has asked you to develop an outline multi-criteria model to help her reach a decision between the options.

The options under consideration are:

Option A: continue the existing system. In one sense this would be the easiest option. However, it also carries some risks as the hospital occasionally experiences times when it runs out of stocks of certain blood types and emergency supplies have to be sent across from the regional hospital. The cost of this is high (because of the specialist transportation needed) contributing to budget overspend and there are also clinical risks for patients. There have also been occasions in some winters where emergency supplies have not been able to be sent because of severe weather conditions.

Option B: expand the blood bank at the local hospital to allow it to carry its own stock requirements in full. The local blood bank would then be effectively independent which would contribute to minimising risk to patients of blood supply shortage. However, the capital cost of this would be high (roughly estimated at about £0.75 million) and in the current economic climate might be difficult to obtain. Once built the hospital would also incur higher annual running costs (again roughly estimated at around £175,000 per year).

Option C: improve the local hospital's Management Information System (MIS) and stock control system (SCS). At present the local hospital does little to try to predict blood use requirements or to manage its blood stocks effectively. This option would focus on two things. First, better analysis and forecasting of blood use requirements in the hospital linked to the scheduling of patient treatments and surgical operations. It is felt that this would enable the hospital to better and more accurately predict the blood it requires. Secondly, investing in an up-to-date stock control system so that blood supplies are more effectively tracked and monitored to reduce wastage, stock levels and associated costs. Most of the effort under this option would go into the development of better IT/IS systems. Anticipated development costs are around £100,000 with ongoing costs on an annual basis of around £50,000.

Question 3.1

3.1 Info: Additional information on the improvement options is as follows:

Option B: Senior medical staff might be unhappy at the additional costs associated with this option, and have commented that the money would be better spent employing more doctors and nurses.

Option C: The exact tangible benefits from this are very difficult to quantify although the manager thinks that wastage will be reduced.

3.1 Task: Which of the improvement options (A, B or C) is preferred, when multiple criteria are used to rank the options, and multiple stakeholder perspectives are considered. Identify at least three criteria/attributes which can be used to rank the three options. Consider the perspectives of at least three potential stakeholder groups for this problem, and identify conflicting interests. Use appropriate software to analyse the problem, and recommend a course of action. Assume values for any data that you do not have, and briefly explain your reasoning for the values that you use.

Question 3.2

3.2 Info: You have been given access to an expert in the hospital on their current blodd transfusion services. The expert has been able to provide some more detailed data on the improvement options, but for some pieces of information, the expert is unsure. The additional information on the improvement options is as follows:

Option A: under this option there is a 10% chance that the hospital has insufficient stock per patient. Specialist transportation of emergency supplies has an average cost of £5,000. In 80% of cases, this arrives within 3 hours and on average there is no detriment to care. Of the remaining cases, 75% of the time emergency supplies arrive between 3 and 6 hours after requested, and the potential delay to treatment incurs an additional expected cost of £20,000 due to lasting health conditions. For the remaining cases, there is a substantial risk to the patient. If the emergency supply can be delivered in time, the potential delay to treatment incurs an additional expected cost of £100,000. However, in 5% of cases, the emergency supplies do not reach the hospital in time and result in a fatality. This cost placed on this outcome is £1.83 million.

Option B: there are three options for the expansion – noted as small, medium and large. The costs described above refer to the medium expansion (£0.75 million for construction, and £175,000 per anum for maintenance). If the medium expansion is in place, the expert predicts that the increased storage capacity would reduce the likelihood of insufficient stock to 5%. The expert does not have data on the small or large expansions.

Option C: under this option, the expert predicts that improved analysis and management would of blood supplies and demand would reduce the likelihood of insufficient stock to 7%.

3.2 Task: Which of the improvement options has the lowest expected value over one year? Over 5 years? Over 10 years? Assume values for any data that you do not have, and explain your reasoning for the values that you use.