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Risk Management in Assembling Juries

Bronwyn Lind

INTRODUCTION

Each year the NSW District Court holds over 1,000 criminal trials. Although only about 25 per cent of persons committed to the District Court on criminal charges actually proceed to trial, the cost of holding trials comprises much more than 25 per cent of the total operational costs of the NSW District Court.

A trial is by far the most expensive method of dealing with a criminal matter. Typically, a trial lasts three to four days but may last many months. Apart from the cost of providing court premises, there are the costs for all personnel involved. These personnel include the judge, the court staff, the prosecution and defence counsel, the witnesses and the jury.

Sometimes trials fail to begin on their appointed listing dates. This may occur for a variety of reasons, for example, the accused may decide to enter a change of plea, from 'not guilty' to 'guilty'; the prosecution or defence may seek an adjournment; or there may be insufficient people to form a jury. Each time a trial fails to go on costs are incurred and court time is often wasted.

While court administrators may have no control over some of the reasons for trials failing to start on their appointed hearing dates, assembling sufficient people to form a jury should be within their control.

This bulletin deals with the particular problem of failing to assemble a jury. The bulletin describes the process for assembling juries for criminal trials in NSW. It then presents a methodology for determining the number of persons who should be summoned for jury duty. Finally the bulletin illustrates the methodology using data from the Sydney and Newcastle District Criminal Courts.

Although the examples in the bulletin are applied to the problem of forming juries for criminal trials, the method is equally applicable to the problem of assembling juries for civil court hearings.

PROCEDURE FOR ASSEMBLING JURIES IN THE NSW DISTRICT CRIMINAL COURT

The current procedure for assembling a jury for the NSW District Criminal Court is as follows. First, a sample of names and addresses is drawn from the electoral roll. Each sample is used for jury selection purposes for a period of time, that is, each sample is used as a pool of potential jurors for a number of jury selections. When a jury is required, a number of people are selected from this sample and asked to attend for jury duty on a specified date. Not all of those asked will be available on the date specified. There are a number of reasons why people may be validly excused from jury duty. Hence some potential jurors may seek and be granted exemption from attending. Some may be excused by the sheriff before the specified date if, for example, a trial is rescheduled. Others may be excused by the sheriff or the judge on the date of commencement of the trial and, finally, there are those who simply do not turn up on the specified date. The jury is selected from those persons who do attend and are not excused. However, as jury membership may be challenged by the prosecution and the defence, for a jury of 12 persons, more than 12potential jurors are required to be available on the date of the trial. At present, in NSW a judge will not begin the procedure of empanelling a jury unless there are at least a sufficient number of potential jurors available to allow for the expected number of challenges.

There are administrative costs associated with the summoning of people for jury duty. These costs include processing, clerical, printing and postage costs, and increase with every additional jury member summoned. Court administrators therefore wish to minimise the numbers of persons summoned but at the same time ensure that there are sufficient numbers of people available on the date of the trial to be able to form a jury.

DEFINING THE PROBLEM

A person is *summoned* for jury duty when he or she is asked to attend on a specified date. That person is *available* for jury duty if he or she is not excused from duty and attends on the specified date. The available persons form the pool of potential jurors from which a jury may be empanelled.

Consider a single attempt to assemble a jury. Let N be the number of persons summoned and A be the number of potential jurors available on the date of the trial. Let p be the proportion of persons available (i.e. $p = A / N$).

Generally, judges will not proceed to empanelling a jury unless there are at least a *minimum* number of persons available from which to select a jury. Let M be this minimum number. For example, in NSW, judges generally require at least 18 potential jurors to be available before proceeding to empanelling a jury of 12 people for a trial involving one accused.

Our problem is that we wish to determine the number, N, of persons to be summoned for jury duty in order to *ensure* that there are at least M persons available on the date of the trial. To solve this problem we must specify an acceptable level of risk (i.e. probability) of there being insufficient numbers of people to form a jury.

The method presented here for resolving this problem is based on statistical probability theory. The next section provides the theoretical basis for the method but it is not essential to an understanding of the method and may be skipped by readers.

THEORETICAL BASIS FOR THE METHOD

It seems reasonable to assume that the probability of a person being available for jury duty, if summoned, varies from person to person. Suppose, then, that person k is summoned for jury duty. Let us now define a random variable X_k such that X_k takes the value one if person k is available for jury duty and the value zero if person k is not available for jury duty. Then, if N people are summoned for jury duty, k takes the values 1 to N and we have N random variables $X_1, X_2, \ldots X_N$. Because each of these variables equals one if the person is available and zero otherwise, their sum is the total number of persons available for jury duty, that is, the total number of available jurors is given by A where:

$$A = X_1 + \ \ldots\ + X_N$$

By application of the central limit theorem it can be shown that the quantity A is normally distributed for large N.[1] Hence, provided that we have estimates of the mean and variance of A it is possible to determine the probability that A is greater or smaller than any specified value.

It follows that the proportion

$$p = \frac{A}{N}$$

is also normally distributed and, similarly, given estimates of the mean andvariance of p, it is possible to calculate the probability that p is greater or smaller than a specified value. Estimates of the mean and variance of p can be obtained using data from real attempts to assemble juries. Note that it will generally be easier to work with the proportion of persons available for jury duty, p, than the actual number of persons available, A, because the number of persons summoned, N, may vary.

Suppose, then, that we have estimates $\hat{p}$ and s^2 for the mean and variance of p. We want to determine the number of persons who should be summoned for jury duty such that the risk of there being insufficient people available to form ajury (i.e. less than M persons available) is held at an acceptably low level. Let α be the acceptable level of risk. The problem is then to determine the value of N for which the probability of there being *at most* (M-1) persons available equals α. This probablity is given by:

$$P\left(p \le \frac{M-1}{N}\right) = \alpha$$

Let $\Phi(x)$ be the probability that a standard normal variable is less than or equal to x and let Z_α be such that $\Phi(Z_\alpha) = \alpha$. Because p can be assumed to be normally distributed with mean $\hat{p}$ and variance s^2, the variable

$$\frac{p - \hat{p}}{s}$$

can be assumed to be a standard normal variable. Then

$$P\left(p \le \frac{M-1}{N}\right) = \Phi\left(\frac{((M-1)/N) - \hat{p}}{s}\right)$$

and this equals α when:

$$\frac{((M-1)/N) - \hat{p}}{s} = Z_\alpha$$

Solving this equation for N gives:

$$N = \frac{M-1}{sZ_\alpha + \hat{p}} \qquad (1)$$

Equation (1) provides the solution to the problem of how many people to summon for jury duty for a specified risk of having too few people (less than M) available to form a jury. At times it will also be convenient to turn the problem around, that is to determine, for a specified number of people summoned for jury duty, the probability of there being too few potential jurors available. This probability can be determined as follows. The probability that there are at least R persons available for jury duty, given N are summoned, is the probability that p is greater than or equal to R/N and this is given by:

$$1 - \Phi\left(\frac{(R/N) - \hat{p}}{s}\right) \qquad (2)$$

DESCRIPTION OF THE METHOD

The method uses the fact that the distribution of p (i.e. the number of persons available for jury duty divided by the number of persons summoned for jury duty) can be assumed to be normal. Using estimates of the mean andvariance of p derived from relevant sample data, the probability of p being greater or smaller than any specified value can then be determined.

It is most important to note that, for the method to be effective, it requires good estimates of the mean and variance of the p values. Clearly, a person's likelihood of being available for jury duty may depend on many factors, for example, the expected length of the trial, its location and when it is to be heard. For example, people may be less likely to be available during summer months because these are popular times for taking holidays. Similarly, people are less likely to be available for long trials than for short trials. Experience in the NSW District Court also indicates that people are more likely to be available for trials in country areas than for those in the city.

Hence when applying this method it is important to use estimates of the mean and variance of the p values derived from data collected for trials of the same type as the one for which a jury is to be assembled. The first requirement of this method, then, is the collection of data for trials of various types. Records should be kept of the numbers of people summoned and the numbers available on the date of the trial, for trials of various types, for example, categorised by expected length of trial, location and time of year.

The specific steps to be undertaken are as follows:

STEP 1. Using a sample of attempts to assemble a jury of the relevant type, calculate, for each attempt, the probability of success, p, where
- $p = A/N$,
- A = the number of persons available for jury duty,

and
- N = the number of people summoned for jury duty.

STEP 2. Calculate the mean, $\hat{p}$, and standard deviation, s, of the p values.

STEP 3. Specify M, the required minimum number of potential jurors. Also specify the probability α where α is the risk one is prepared to take that there will not be sufficient people available to form a jury. (In other words α is the probability that there are less than M potential jurors available.)

STEP 4. Calculate N, the number of jurors to be summoned using the following formula:

$$N = \frac{M - 1}{sZ_{a} + \hat{p}} \qquad (1)$$

where Z_{α} is such that there is probability α of a standard normal variable being less than or equal to Z_{α}. Values of Z_{α} can be found in statistical tables of the normal distribution function. A function for Z_{α} is included in most standard computer spreadsheet applications.[2]

It is also possible, given the number of people summoned, N, and the number of people required, R say, to calculate the probability of there being *at least* R people available for jury duty. This probability is given by:

$$1 - \Phi\left(\frac{(R\,/N) - \hat{p}}{s}\right) \qquad (2)$$

where $\Phi(x)$ is the probability that a standard normal variable is less than or equal to x. For any value of x, $\Phi(x)$ can be determined from statistical tables of the normal distribution function. A function giving the value of $\Phi(x)$ is usually included in standard computer spreadsheet applications.[3]

ILLUSTRATION OF THE METHOD

Consider two examples, one drawn from the Sydney District Court and one from the Newcastle District Court.

Table 1 shows jury data for a sample of 100 trials in the Sydney District Court. It shows, for each trial, the number of persons summoned for jury duty (N), the number of persons who were available for jury duty on the date of commencement of the trial (A) and the proportion p of persons available (= A / N). Table 2 shows similar data for a sample of 100 trials in the Newcastle District Court.

The sample mean and standard deviation of the calculated p values are also shown at the bottom of each table. It can be seen that the mean p values for Sydney and Newcastle are quite different. On average about 33 per cent of persons summoned were available for jury duty in Sydney compared with 57 per cent in Newcastle. The standard deviations were similar indicating that the variation in the p values was about the same for the two cities.

Table 1: Sample jury data for Sydney District Court

Summoned (N)	Available (A)	Estimate of p (= A/N)	Summoned (N)	Available (A)	Estimate of p (= A/N)
60	8	0.13	60	19	0.32
60	8	0.13	55	18	0.33
55	8	0.15	60	20	0.33
20	3	0.15	60	20	0.33
20	3	0.15	60	20	0.33
55	9	0.16	60	20	0.33
60	11	0.18	55	19	0.35
60	12	0.20	60	21	0.35
55	11	0.20	20	7	0.35
55	11	0.20	55	20	0.36
20	4	0.20	55	20	0.36
60	13	0.22	55	20	0.36
60	13	0.22	60	22	0.37
60	13	0.22	55	21	0.38
55	12	0.22	55	21	0.38
60	14	0.23	60	23	0.38
55	13	0.24	60	23	0.38
55	13	0.24	60	23	0.38
55	13	0.24	100	40	0.40
20	5	0.25	60	24	0.40
60	15	0.25	60	24	0.40
60	15	0.25	60	24	0.40
20	5	0.25	60	24	0.40
20	5	0.25	60	24	0.40
55	14	0.25	60	24	0.40
55	14	0.25	60	24	0.40
60	16	0.27	20	8	0.40
60	16	0.27	60	24	0.40
55	15	0.27	55	22	0.40
55	15	0.27	55	22	0.40
55	15	0.27	60	25	0.42
60	17	0.28	55	23	0.42
60	17	0.28	60	26	0.43
55	16	0.29	60	26	0.43
55	16	0.29	55	24	0.44
55	16	0.29	60	27	0.45
20	6	0.30	20	9	0.45
60	18	0.30	20	9	0.45
20	6	0.30	60	28	0.47
60	18	0.30	60	29	0.48
20	6	0.30	60	29	0.48
20	6	0.30	60	29	0.48
20	6	0.30	60	30	0.50
55	17	0.31	20	10	0.50
55	17	0.31	60	31	0.52
60	19	0.32	60	32	0.53
60	19	0.32	60	32	0.53
60	19	0.32	20	11	0.55
60	19	0.32	60	33	0.55
60	19	0.32	20	11	0.55

average p = 0.3335 standard deviation of p = 0.1023

Table 2: Sample jury data for Newcastle District Court

Summoned (N)	Available (A)	Estimate of p (= A/N)	Summoned (N)	Available (A)	Estimate of p (= A/N)
20	5	0.25	45	26	0.58
45	13	0.29	45	26	0.58
45	15	0.33	45	26	0.58
45	18	0.40	45	26	0.58
20	8	0.40	45	26	0.58
20	8	0.40	45	26	0.58
45	19	0.42	45	27	0.60
60	26	0.43	20	12	0.60
45	20	0.44	20	12	0.60
45	20	0.44	45	27	0.60
60	27	0.45	45	27	0.60
45	21	0.47	60	36	0.60
45	21	0.47	45	27	0.60
45	21	0.47	45	28	0.62
45	21	0.47	45	28	0.62
45	21	0.47	45	28	0.62
60	29	0.48	45	28	0.62
60	29	0.48	45	28	0.62
45	22	0.49	45	28	0.62
45	22	0.49	45	28	0.62
45	22	0.49	50	32	0.64
20	10	0.50	45	29	0.64
45	23	0.51	45	29	0.64
45	23	0.51	45	29	0.64
45	23	0.51	45	29	0.64
45	23	0.51	45	29	0.64
45	23	0.51	45	29	0.64
45	23	0.51	20	13	0.65
45	24	0.53	20	13	0.65
45	24	0.53	50	33	0.66
45	24	0.53	45	30	0.67
60	32	0.53	45	30	0.67
45	24	0.53	45	30	0.67
20	11	0.55	45	30	0.67
20	11	0.55	45	30	0.67
20	11	0.55	45	30	0.67
20	11	0.55	45	30	0.67
45	25	0.56	45	30	0.67
45	25	0.56	45	31	0.69
45	25	0.56	45	32	0.71
45	25	0.56	45	32	0.71
45	25	0.56	45	32	0.71
45	25	0.56	45	32	0.71
45	25	0.56	45	33	0.73
45	25	0.56	45	33	0.73
45	25	0.56	45	33	0.73
60	34	0.57	45	34	0.76
45	26	0.58	45	34	0.76
45	26	0.58	30	23	0.77

average p = 0.5729 standard deviation of p = 0.1003

The sample means and standard deviations for Sydney and Newcastle have been used to calculate the results shown in Table 3. For demonstration purposes it has been assumed here that the minimum number of potential jurors is 18, that is, that there must be at least 18 people available before the judge will proceed to empanelling a jury. The table shows the numbers of people who should be summoned for jury duty, for various levels of risk of there being less than 18 people available for jury duty.

It is clear that there are substantial differences between Sydney and Newcastle. For a one per cent risk of not being able to form a jury, 178 people must be summoned in Sydney, more than three times as many as must be summoned in Newcastle (51). The different results for Sydney and Newcastle clearly demonstrate the importance of good local estimates of p. If the Newcastle estimate of p were used in Sydney far too few people would be summoned for jury duty. For example, if only 51 people were summoned for jury duty in Sydney the probability of there being at least 18 people available for jury duty would be only 42 per cent (calculated by substitution in equation (2)).

It is also clear from Table 3 that, if we are willing to tolerate a higher risk of there being too few potential jurors available, fewer numbers of people need to be summoned. For example, for a ten per cent risk of the trial failing to go ahead as scheduled, only 84 people need to be summoned for jury duty in Sydney, less than half the number required for a one per cent risk. However, if only 84 people were summoned every time a jury was required in Sydney then, on average, one trial in every ten would not be able to go ahead.

In most cases the time and travel costs of an excess number of people turning up for jury duty would outweigh the cost of a trial failing to go on as scheduled. Hence court administrators should generally aim to specify a very small risk of failing to form a jury.

Figure 1 illustrates the relationship between the number of persons who should be summoned for jury duty and the risk of failing to form a jury, for a greater range of specified risks than is shown in Table 3. The figure shows that as the acceptable risk of failing to form a jury increases, the number of people who need to be summoned for jury duty decreases. The rate of decrease is very rapid for very small risks, then more gradual as the risk increases. For

Table 3: Number of persons who should be summoned for jury duty

	Probability of there being less than 18 people available for jury duty			
	0.01	***0.05***	***0.10***	***0.20***
Sydney	178	103	84	69
Newcastle	51	42	39	35

example, Figure 1 clearly shows that, for Sydney, very large numbers of people would need to be summoned if the specified acceptable risk were very small (less than one chance in 100). However there is relatively little change in the number of people to be summoned for risks greater than 20 per cent (more than one chance in five).

EXTENSION OF THE METHOD TO SELECTION OF MULTIPLE JURIES

So far we have only considered the problem of assembling juries for single trials. The Sydney District Court has a multi-court complex and it is usual to schedule more than one trial to start on the same day.

The method of determining the number of people to be summoned can be extended to the case of assembling juries for a number of trials *provided the trials are of the same type*. As in the one-jury case, it is only necessary to specify both the minimum number of potential jurors who need to be available and the acceptable level of risk of failing to form *all* the juries required.

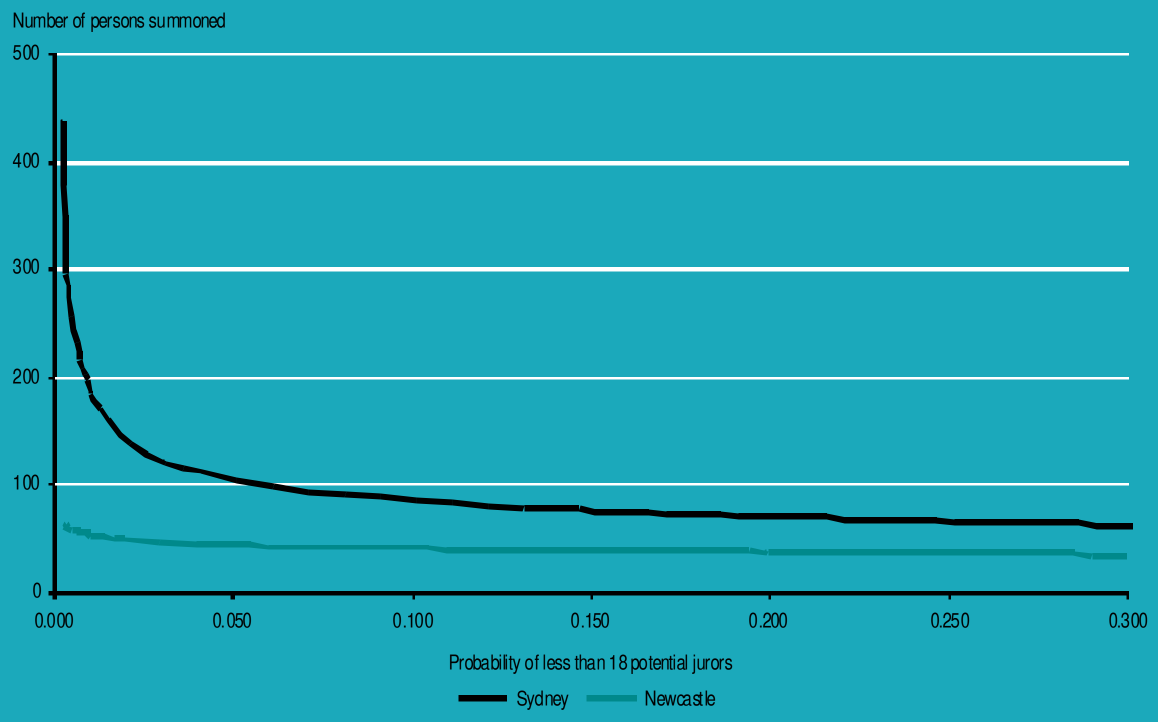
There are economies of scale when several juries are to be assembled. Because all the people summoned form a pool from which the multiple juries are assembled, any person not needed for the first jury becomes available for the second jury and so on.

Suppose, for example, that five trials of a similar type are scheduled to start on a specified date. Let us assume that the minimum number of persons required to be available for jury duty on that date is 80 (this number allows for 20 persons to be rejected following challenges to jury membership, over and above the 60 members of five 12-person juries). For an acceptable risk of say one per cent, we can calculate that, for Sydney, 828 people would need to be summoned. By contrast, for five separate juries each requiring 18 potential jurors available, there would need to be 890 (=178 x 5) people summoned for jury duty. Hence in this example, 62 fewer people would need to be summoned for five trials in a multi-court complex than for five trials held in separate courts.

SUMMARY

In order to determine the number of people who should be summoned for jury duty, the only requirements are:

Figure 1: Number of persons to be summoned for varying risk of failing to form a jury



- estimates of the mean and standard deviation of the proportion of jurors available for jury duty, based on historical records for trials of the same type
- the minimum number of people required to be available in order to form the jury (or juries)
- the acceptable level of risk that the required jury (or juries) cannot be formed.

Anyone with queries about or an interest in applying the methodology described here is welcome to contact the Bureau for further advice.

NOTES

1 See, for example, Feller W. 1962, *An Introduction to Probability Theory and its Applications* Volume I, 2nd edn, John Wiley & Sons Inc., New York, p. 239.

2 In *Microsoft EXCEL* the function is NORMSINV(α).

3 In *Microsoft EXCEL* the function is NORMSDIST(x).

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NSW Bureau of Crime Statistics and Research
Level 8, St James Centre, 111 Elizabeth Street, Sydney 2000 Tel: 231-9190

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