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The Good, The Bad, and the Dentist

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THE GOOD, THE BAD, AND THE DENTIST

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ABSTRACT

Missed appointments create many problems in dental practices, as those patients who fail to turn up deprive other patients of an opportunity for treatment. This paper reports on a study of failures to attend appointments without giving advance notice in a NHS practice in the UK. A sample of 588 patients is analysed using Logit and Distribution Mixtures in order to devise policies to improve no-show rates. It is shown that a policy based on de-registration of patients who fail to attend an appointment would be justified on statistical grounds and would work in the long run, but that such policy would not improve things in the short run and can make them worse. The paper also discusses emergency treatment and workload at the practice.

Keywords: Appointments and schedules, Dental clinics, Distribution Mixtures, National Health Service.

Running head: Missed appointments at a NHS dental clinic.

INTRODUCTION

Dental health in the United Kingdom is provided in part by privately run practices, and in part by practices integrated within the National Health Service (NHS). NHS treatment is subsidised by the state: the patient makes a contribution to cost and this is limited to a maximum amount. Treatment in a private practice is not subsidised and can be very expensive. For this reason, many individuals would prefer to be treated under the NHS. But there is an excess demand over supply of NHS dental services in the UK and not everybody who would like to register with a NHS practice can do so.

Each NHS dental practice is allocated a number of potential patients. Practitioners derive about 20% of their income through capitation fees, the other 80% of the income being related to the type of treatment provided. There is a scale of charges for each item of treatment. These charges are negotiated annually by the Department of Health together with representatives of the Dental profession, and are set in such a way that the average practice should earn an average target income.

Patients who fail to honour an appointment create a series of problems. First, they are depriving another patient- who, perhaps, has to be privately treated- of the opportunity to receive NHS treatment. Second, since 80% of the dentist's income is treatment-related, by not showing up they are causing a loss of income to the practice. Third, as patients who fail to honour appointments will, perhaps, want to be treated later, they contribute to the development of long waiting lists for dental services.

The problem of failed appointments has been studied before, albeit not necessarily in a U.K. dental context. A series of risk factors have been identified. Some studies find

a relationship between patient gender and failure to attend, but most find no difference between men and women in this respect; Hertz and Stamps (1977), Oppenheim et al. (1979); Goldman et al. (1982). Age appears to be important: both the old and the young appear to have higher failure rates than the in-between group; Carne (1967), Hurtago et al. (1973), Goldman et al. (1982), Bickler (1985). Higher failure rates have also been found amongst people of lower socio-economic status- Hurtago el a. (1973), Oppenhein (1979), Gilhooly et al. (1994)- and amongst the less educated- Deyo and Inui (1980). Other risk factors that have been studied are: having young children at home- Cosgrove (1990), Gilholly et al. (1994)-; access to a telephone- Hertz and Stamps (1977), Mars and Channing (1986), Cosgrove (1990)-; employment status- Frankel et al. (1989); and urgency of the appointment; Oppenheim (1990). Of particular interest for this study are the findings that patients who have not long been registered with the practice are more likely to default on appointments- Oppenheim et al. (1979), Bickler (1985)-; that patients who have failed to keep their appointments in the past are less likely to turn up to the forthcoming one- Cosgrove (1990), Goldman et al. (1982)-; and that long intervals between appointments are associated with higher failure rates; Oppenheim et al. (1989). Finally, other risk factors observed include day of the week, the weather, and weather the practice is in a rural or urban environment. Guse et al. (2003) give an extensive review of the literature on this subject.

This study concerns a NHS dental practice in Southampton. A dental practitioner was worried about the number of patients who had not kept an appointment and had failed to cancel it. A series of issues put themselves forward for analysis. Is the probability of failing to keep an appointment in this practice associated with such personal

characteristics as sex, and age? Are patients who failed to honour an appointment in the past more likely to fail to honour the coming appointment? Is there any action that the dentist can take in order to reduce failure rates? In particular, the dental practitioner was thinking of implementing a policy of excluding from the practice's list all those patients who had failed to attend three appointments without giving previous notice.

This study attempts to estimate the probability that a patient of given personal characteristics and with a given appointment history, has of keeping a forthcoming appointment in the practice. In order to do so, past records were examined and analysed using a series of statistical methods that include Logit analysis, and distribution mixtures. The data is described after this introduction. This is followed by an account of the Logit study and its findings. The possible existence of two calling populations, one of patients that keep their appointments and another one of patients that fail to keep them, is next discussed. This is followed by a discussion of practitioner's workload, which also takes into account emergency arrivals. The paper ends with a concluding section that summarises the findings.

THE DATA

The general dental practice whose data was analysed kept records for about 3000 patients. The practice had been in operation for two and a half years before the study was undertaken. The average patient had been registered for 25 months. A random sample of 598 patients was collected. Of these, 10 patients had to be removed from the study because of data deficiencies, reducing the sample to 588 patients. The final

data set included 263 males and 325 females and covered the range of 2 to 95 years old.

For each patient, details on age and sex were collected from the records. The full story of kept and missed appointments was also recorded, although not the dates when the appointments took place.

No data was collected on social class, family commitments, employment status, or other personal characteristics. The purpose of the study was not only the study of the patterns of failed and kept appointments, but also to devise policies to keep down the number of missed appointments, and it would not have been acceptable to base such policies on marital status, or socio-economic characteristics, or even day of the week.

The information was coded and entered in the SPSS package for analysis.

WHAT DETERMINES ATTENDANCE AT THE FORTHCOMING APPOINTMENT?

The situation is quite straightforward: given that we know the age, sex, and appointment history for a patient, what is the probability that this patient will miss the forthcoming appointment?

In order to answer this question, a binary variable (LAPP) was defined in such a way that it took the value one if the patient had failed to keep the latest appointment in the records and the value 0 if the patient had turned up to the latest appointment in the records. Explanatory variables were SEX- 1 if female and 0 if male-; AGE; total

number of previous appointments (APP); and total number of previous appointments missed (MISSES). APP and MISSES excluded the last appointment.

The data set was analysed using Logit regression. The dependent variable was LAPP. Explanatory variables were AGE, APP, MISSES, their squares, and their cross products. Squares and cross products were included in order to account for possible non-linearities and interactions. SEX was also included as an explanatory variable. We had no expectations about the coefficient of the variable SEX, previous studies being inconclusive in this respect. The impact of the AGE variable was expected to be non-linear, as higher failure rates have been found in the past for the old and for the young, and lower for the in-between group. The total number of appointments and the total number of previous failures was also expected to be important, in line with the results observed in the literature. The model was estimated using 90% of the observations. The remaining 10% of the observations was a random sample kept for validation purposes.

Modelling proceeded from the general to the particular. This way of proceeding has can be on the grounds that it is statistically sound to test for simplifications in a model that includes more variables than necessary. The alternative strategy, proceeding from the particular to the general has the disadvantage that, because of missing variable bias, the results observed may depend on the absence of a variable whose significance has not been tested. Automatic variable selection methods were discarded on the grounds that we want to be fully aware of the decisions made at the modelling stage and their implications.

The full model, which included all the explanatory variables, their squares, and the interaction terms, correctly classified 91% of the observations in the estimation sample, and 87% of the observations in the validation sample. As expected, the coefficient of SEX was found to be non-significant. This variable was removed from the data set and the model was re-estimated. The next variable to drop out was the interaction term APP*AGE, followed by AGE*MISSES, and MISSES*APP. This indicates that there are discernible interactions in the data set.

AGE, APP, MISSES and their squares had coefficients that were asymptotically significantly different from zero in the final model. However, MISSES had by far the largest impact on the model. AGE and its square were significantly associated with the probability to fail to attend the next appointment, but this creates a problem for the dentist, as she could not justify the decision not to accept a patient on the basis that the patient is too young or too old. In line with this, AGE and its square were removed from the data and the coefficients were re-estimated. The final model correctly classified 91% of the observations in the estimation sample and 89% of the observations in the validation sample. The removal of SEX had very little impact on the remaining coefficients and on the classificatory ability of the model.

Having established that a model that contained only the number of previous appointments and the number of previous misses was appropriate, it was re-estimated using the complete data set, which included observations previously used for estimation together with observations previously used for validation. The final results are given in Table 1.

Variable	B	S.E.	Wald	df	Sig.	Exp(B)
APP	-.642	.105	37.256	1	.000	.526
APP^2	.013	.003	17.265	1	.000	1.013
MISSES	4.773	.563	71.868	1	.000	118.308
$MISSES^2$	-.721	.134	28.864	1	.000	.486
Constant	-2.123	.451	22.206	1	.000	.120

Table 1. - Results of Logit Analysis. SPSS output.

It can be seen from Table 1 that the probability of missing the forthcoming appointment increases with the number of previous misses and decreases with the number of previous appointments. This is in line with what would have been expected.

The results of the Logit model were used to calculate, for various levels of previous misses and for various numbers of previous appointments, the probability that the patient will attend the next appointment. The results are given in Table 2.

	MISSES				
APP	**0**	**1**	**2**	**3**	**4**
0	0.893				
1	0.940	0.214			
2	0.966	0.332	0.035		
3	0.981	0.470	0.061	0.020	
4	0.989	0.606	0.102	0.034	0.044
5	0.993	0.722	0.161	0.056	0.073
6	0.996	0.811	0.240	0.089	0.114
7	0.997	0.873	0.336	0.136	0.171
8	0.998	0.915	0.442	0.197	0.244
9	0.999	0.942	0.546	0.272	0.330
10	0.999	0.960	0.641	0.357	0.422
11	1.000	0.972	0.721	0.446	0.514

Table 2. - Probability that a patient will attend an appointment.

It is clear from Table 2 that a patient who has missed two appointments is very unlikely to attend the third appointment. It would, therefore, be justified, to devise a policy along the lines that any patient who fails to keep two appointments is removed from the practice's list. The Dental Practitioner, however, preferred a policy of excluding a patient from the list only if three appointments have been missed. Such a policy would be perfectly justified on the basis of the statistical results just described.

THE GOOD, THE BAD, AND THE LIKELY

A criticism of the Logit model is that the full richness of the data has not been exploited. The decision rule has been based only on information about the last appointment. If we accept that a policy on inclusion in, and exclusion from, the practice's list can be based on the number of appointments kept and missed, is there a way in which we can base our analysis on observation of the full data set and not only on the last appointment?

The practice wants to implement a decision rule in such a way that patients who fail to honour a certain number of appointments will be excluded from the list. This, implicitly, assumes the existence of two populations: a population of patients who are reliable and keep their appointments but can miss the odd one for reasons beyond their control (the good); and a population of unreliable patients who do not keep their appointments and are wasting everybody's time (the bad). Under this simplified word, can we estimate the relative proportions of the two populations? Can we find the probability that a "good" patient has of missing an appointment, and the

probability that a "bad" patient has of missing an appointment? This indeed can be done using the technique of Maximum Likelihood; Edwards (1976).

Take a particular patient, i, who has been given an appointment. There is a probability that the patient will turn out to the appointment, θ, and a probability that the patient will not turn out to the appointment, 1-θ. We assume that, for a given patient, the probability that he/she will turn up remains unchanged, and we further assume that all "good" patients have the same probability of turning up, θ_1, and that all "bad" patients have the same probability of turning up, θ_2. We are thus defining the sequence of observations for a patient as the observation of a series of Bernouilli trials. If the proportion of "good" patients in the population is π and the proportion of "bad" patients is 1-π, we can write the likelihood for the sequence of observations associated with this patient as:

$$p\, q_1^{s_i}\, (1-q_1)^{n_i-s_i} \;+\; (1-p)\, q_2^{s_i}\, (1-q_2)^{n_i-s_i}$$

where n_i is the total number of appointments for patient i, and s_i is the total number of appointments that patient i has honoured. This statement says that the patient's sequence could have been observed from the good population with probability π, or from the bad population with probability 1-π. Since we have one such sequence for each patient, the likelihood for the complete data set is:

$$l\,(p,q_1,q_2) = \prod_{i=1}^{n}\left[p\, q_1^{s_i}\, (1-q_1)^{n_i-s_i} \;+\; (1-p)\, q_2^{s_i}\, (1-q_2)^{n_i-s_i}\right]$$

All we require is, for each patient, the number of appointments kept and the number of appointments missed. The numbers can be deduced from Table 3.

Number of appointments	Number of misses				Row total
	0	**1**	**2**	**3**	
1	29	3			32
2	33	9	0		42
3	41	12	0	0	53
4	47	15	1	1	64
5	61	17	6	1	85
6	42	17	6	1	66
7	28	13	4	3	48
8	26	16	10	4	56
9	30	5	4	3	42
10	11	4	3	2	20
11	8	5	6	2	21
12	6	4	4	0	14
13	4	1	6	1	12
14	3	2	4	0	9
15	3	4	0	0	7

Table 3. - Number of appointments and number of misses

We need to estimate the values of π, θ_1, and θ_2 that maximize the likelihood function, but rather than work with the direct likelihood, we maximize its logarithm. The log likelihood function is a mixture of additive and multiplicative terms and cannot be solved in an analytical way. We have to resort to numerical methods.

A first attempt to estimate maximum likelihood values for the parameters using the computer package MatLab without imposing restrictions on their values ended in failure when the package returned probabilities outside the [0,1] range. Everitt (1993) points out that it is difficult to estimate the likelihood associated with a mixture of distributions, such as the one we have in this case, since the algorithms are known to

have convergence problems and to get stuck at local optima. To ensure that parameters stayed within the range of acceptable values, the parameters were constrained to be between zero and one, and an appropriate MatLab routine was used to re-estimate the model, but this time the algorithm failed to converge. In the end, the function had to be graphed and its optimum found through a grid search.

It was found that the maximum likelihood estimate for θ_1 was 1; i.e., good patients never miss an appointment. The equivalent probability for a "bad" patient, θ_2, was 0.88; i.e., bad patients have a probability of 0.12 of missing an appointment. The proportion of "good" patients in the population was estimated to be 0.31; i.e., 69% of the population is made up of "bad" patients and 31% of the population is made up of "good" patients.

The question arises if the two-population model is statistically justified, or if a single population is observed with random variation. The likelihood associated with a single population is obtained by setting π equal to 1 in the two-population model. The likelihood now contains a single parameter, θ_1, whose estimator can be proved to be the average number of attendances in the sample, 0.9174. The likelihood ratio test, based on comparing the restricted model (one population) with the unrestricted model (two populations), rejected at the 1% level the hypothesis of a single population. We conclude that it is reasonable to work under the assumption that the practice faces two types of patients: the reliable and the unreliable. Kinney et al. (2001) studied failure to keep appointments in a Community Health Centre in the USA and also found support for the two-population hypothesis.

A possible policy rule that follows from these findings is one of no tolerance. A patient who misses an appointment shows that he/she is unreliable and can be excluded from the NHS to allow a "more deserving" potential patient to take its place. If the population of registered patients is a fair reflection of the general population, this policy of no tolerance is likely to work in the long run, as a bad patient will be thrown out at the first opportunity but only has a 69% chance of being replaced by another bad patient. Under the assumption that the population in the sample is representative of the general population we can calculate the probability that a newly registered patient with no previous history has of keeping the appointment:

$$1* 0.31+0.88* 0.69 = 0.92$$

This is higher than the 0.89 shown in Table 2 for failure to keep the first appointment when the number of previous appointments was zero. This difference could be due to random variation or could indicate that the proportion of "bad" patients in the general population is higher than the proportion of "bad" patients in the practice. If the difference is due to random variation, the policy of excluding from the list "bad" patients will, in the long run, improve attendance rates; but if the difference is due to the fact that the population at large is more unreliable, then a policy of excluding patients who fail will only make things worse before they get better.

EMERGENCIES, WORKLOAD, AND OVERBOOKING.

Patients who come to see the dentist with a previous appointment, and patients who have an appointment but fail to turn up, are only part of the workload of the practice. If all patients were to turn up to their appointments, the dental practitioner would see 16 patients in a session, a session being either the morning or the afternoon. Each

patient has a probability of turning up or not turning up to the appointment; by examining the record card for each patient, we could determine this probability. We can say that each session is a sequence of 16 Bernouilli trials, each with a given probability of success on the basis of the patient's previous appointment history. But, for argument shake, and in the absence of better evidence, we could take as the probability of attendance at the appointment the average found in the sample, 0.9174. Under this assumption, the expected number of attendances in a session is 14.68. This is just over one patient short of the number expected.

We can now consider emergencies. Some individuals turn up for emergency treatment without a previous appointment, and are fitted within the gaps in the schedule. The distribution of such patients is well described by a Poisson distribution with parameter 1.953; i.e., on average we expect about two patients to turn up for emergency treatment in a session.

It appears that, on average, patients who miss an appointment do not create a problem since they make room for other patients who need emergency treatment. We could also say that, on average, both processes almost balance each other. But we must not forget that beyond average numbers there are the horrors of the waiting room. The convolution of the Bernouilli and the Poisson distributions shows that 90% confidence limits for the number of patients in a session include the range 12 to 19. This is quite a substantial variation and, indeed, this variation motivated the present study in the first place. It is to be noted that if the dental practitioner decides to overbook, numbers as low as 12 will be avoided, but she will have to pay for it in terms of long working hours, as the upper confidence limit also increases.

CONCLUSION AND DISCUSSION

Non-attendance by pre-booked patients at a dental practice motivated this study. The dental practitioner suspected that her patients could be classified into those who systematically keep an appointment and those who do not cancel and do not show up. Given that the dental practice operated under the NHS system, and that the demand for NHS dental treatment far exceeded supply, the practitioner wanted to devise policies that would minimise the number of lost opportunities for treatment.

It has been seen that, as the dental practitioner suspected, the number of previously missed appointments gives a good indication of future failures to attend. The higher the number of previously missed appointments, the lower the probability that the patient will attend the forthcoming appointment. It has also been seen that there is a "customer loyalty" effect. The longer a patient has been with the practice, the lower is the probability that the patient will miss the forthcoming appointment.

Some personal characteristics of the patient are known to be associated with failure to attend and, in this study, age has been shown to have a significant effect. But it was not considered acceptable to differentiate between patients on the basis of characteristics such as age, employment status, or level of education. Richardson (1998), however, does not share this opinion and suggests that unreliable patients should be identified and overbooked in special sessions.

What can be done? A possible policy is to remind patients of their forthcoming appointments, but all patients have to be reminded, those who are reliable and those who are unreliable, and there is no evidence that the reminders would improve the behaviour of the unreliable ones, or that the benefits of this policy will exclude its costs. The study suggests that a policy of zero tolerance- one failure to attend and you are out- would be justified. Again, this policy was found not to be acceptable on ethical grounds. The dental practitioner would prefer a policy of deregistration after three failures to attend. This, the analysis shows, will be effective in the long run, but in the short run is likely to make things worse, as indeed it happened when the policy was implemented.

Another aspect that has been discussed is emergencies. In the same way that some patients do not turn up when expected, others turn up when they are not expected. On average both processes almost cancel each other. This would be a good thing were it not for the stochastic nature of both processes. It has been shown that the dental practitioner can aspect both very long days and lots of failed appointments on a normal session.

Apart from analysing the system, there is little that the research could do for the dental practice. Life is full of uncertainty, particularly the future, and it has to be accepted the way it comes.

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