THEORY AND METHODS

Investigating the relation between placement of Quit antismoking advertisements and number of telephone calls to Quitline: a semiparametric modelling approach

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Study objectives: Quitline—an antismoking advertising and a telephone helpline service—is an effective public health intervention strategy for tobacco control. The objective of this short report is to model the relation between placement of antismoking advertisements and calls to Quitline on a given day.
Methods/design: Data on daily Quitline antismoking advertisements, television target audience rating points (TARPS), and calls to Quitline Victoria were studied for the period 1 August 2000 and 31 July 2001. The outcome—calls to Quitline—is a count and thus assumed to follow a Poisson distribution. Generalised partial linear models were used to model the logarithm of mean daily calls as a non-parametric function of time and a linear parametric function of the day of week, number of advertisements, and TARPS.
Main results: Peak calls to Quitline Victoria occurred during Monday to Wednesday with around three times as many calls compared with Sunday. Both placement of Quitline advertisements ($p<0.001$) and an increase in TARPS ($p<0.001$) on a given day significantly increased the number of calls made to Quitline Victoria. The model adequately captured fluctuations in call volume and diagnostics showed no model inadequacy.
Conclusions: In this short report the emphasis is on modelling the parametric components—day of week, placement of advertisements, and TARPS on call volume. The dynamics of the underlying time trend in call volume is captured in a non-parametric component. Future analysis of hourly data would provide additional information to assess different media buying strategies that might increase call volume.

For more than a decade, Quitline services, a population based telephone support programme to promote smoking cessation, have been a focal point of tobacco control intervention strategies in a number of US cities, England, Australia, the Netherlands, and more recently in Asia.[1–5] Implementation of mass media advertising campaigns to encourage quitting behaviour that are supported by telephone helpline services are cost effective and widely accessible to the population as a first point of contact to a quit smoking service.[6]

The effectiveness and successful uptake of these programmes have been shown in earlier studies[7 8] but few have focused on understanding and predicting the relation between placements of antismoking advertisements and the number of telephone calls to a Quitline.[4 9] Unravelling these relations is a challenge methodologically, particularly as all vary by time (hour, day of week, and season). In addition, the inclusion of the target audience rating points (TARPS), which estimates the reach and frequency of televised advertisements to the population, is necessary to fully understand strategies that might increase call volume.

However, it is necessary to ensure continual success of these programmes in terms of resource allocation and cost efficiency because advertising expenditure is often purchased on the basis of cost, target audience, and reach. Models that predict the number of calls on a given day will permit prior planning of staffing levels to adequately service call volume. In addition, modelling call volume under different advertising placement scenarios will allow Quitline to determine the optimal number and placement of advertisements in line with TARPS, necessary for a cost effective telephone line service. Using semiparametric models we present results on the relation between total number of calls to Quitline and total number of antismoking advertisements on a given day.

METHODS

Data

Daily total number of calls to Quitline Victoria (outcome variable), total number of Quit antismoking advertisements on free to air television, and TARPS were available for the period 1 August 2000 and 31 July 2001.

Statistical methods

The distribution of the daily number of calls had a strong positive skew (not shown), and was not amenable to transformation to normality. Therefore linear regression methods were not appropriate. As the outcome variable—number of calls to Quitline—is a count (discrete variable) a more suitable method is the Poisson regression model, which has two components: mean and variance. Total number of Quit advertisements, TARPS, day of week, and an overall time trend for the duration of the study were considered as potential covariates in the analysis. In addition, two way interactions between day of week and total number of Quit advertisements were considered as potential covariates.

We used a flexible generalised partial linear model[10] to model the logarithm of the mean daily number of calls as a non-parametric function of time and as a linear parametric function of covariates. To account for possible overdispersion in the data we used a quasi-Poisson model that permits the variance to be a polynomial function of the mean.

The non-parametric component was modelled using a local regression method with the nearest neighbour fraction of 0.03 and a tricube weight function. Model adequacy was assessed by examining a plot of residuals compared with fitted values, a Q-Q normality plot, and plots of the autocorrelation and partial autocorrelation functions of the residuals. All analyses were carried out using LOCFIT[11] to specify the smooth term in the generalised additive models

Table 1 Results of a generalised partial linear regression model of daily total number of calls to Quitline Victoria and daily number of antismoking Quit advertisements, adjusting for day of week effects, TARPS, and any interactions

Variable	Coefficient	Standard error	p Value	95% CI	Exp (coeffiicent)
Intercept	3.344	0.046	<0.001	(3.253, 3.434)	28.332
Sunday	−0.051	0.057	0.26	(−0.162, 0.060)	0.950
Monday	1.081	0.053	<0.001	(0.977, 1.184)	2.947
Tuesday	1.084	0.053	<0.001	(0.981, 1.187)	2.956
Wednesday	1.159	0.051	<0.001	(1.058, 1.259)	3.187
Thursday	1.025	0.050	<0.001	(0.927, 1.124)	2.787
Friday	0.811	0.050	<0.001	(0.713, 0.910)	2.250
TOTADS*	0.007	0.002	0.003	(0.003, 0.011)	1.007
Sunday × TOTADS*	0.023	0.006	<0.001	(0.011, 0.035)	1.023
TARPS	0.006	0.001	<0.001	(0.005, 0.007)	1.006

*Quit antismoking advertisements.

(GAM) procedure and simultaneously estimate the parameters in the linear function of the covariates[10] as implemented in the R statistical computing package.[12]

RESULTS

Preliminary analysis

On average, peak number of calls occurred on Mondays (mean (SD): 113.5 (62.5)), Tuesdays (115.9 (68.2)), and Wednesdays (107.4 (66.1)). Coinciding with these peaks were more Quit antismoking advertisements during Mondays (10.8 (10.3)), Tuesdays (10.2 (9.7)), and Wednesdays (8.2 (8.3)).

Figure 1 shows a plot of the daily number of calls to Quitline between August 2000 and July 2001 (lower solid line). Two distinct peaks around New Year are apparent; the earlier peak in number of calls is expected as Quit advertisements aired a few days earlier, while the later coincides with the New Year period. Another on 31 May corresponds to World No Tobacco Day with lots of public relations activity during this time. Other notable trends include the opening ceremony and duration of the Sydney Olympics during late September and the trough in the first two weeks of April was in the lead up to Easter Sunday on 15 April. Mean number of calls to Quitline varies across days of the week by more than a factor of 3, and more advertisements and more TARPS were associated with more calls to Quitline.

Semiparametric models

Initially the parametric component consisted of a full model with interaction terms. However, interaction terms between day of week and total number of Quit advertisements were not significant (except for Sunday and total number of Quit advertisements) and are thus excluded from the model presented. Table 1 shows the estimated day of week, total number of Quit advertisements, TARPS, and interaction effects of the final model.

The numbers of calls made on each day, except Sunday ($p = 0.3$) were significantly different to number of calls on Saturdays, with around three times as many calls on Monday to Thursday nights. Both total number of Quit advertisements ($p = 0.003$) and TARPS ($p<0.001$) were positively associated with total number of calls to Quitline. An interaction term between Sunday and total number of Quit advertisements was also associated with increased calls ($p = 0.0004$). As we have used log-linear models the effects are multiplicative. Thus on a Sunday with no advertisements and zero TARPS level we expect $0.95 \times 28.332 = 26.915$ calls. However, if there were six Quit advertisements generating 20.1 TARPS on a given Sunday we expect $28.332 \times 0.950 \times \exp(0.007+0.023)^{6} \times \exp(0.006)^{20.1} = 36.35$ calls. On a Monday with no advertisements we expect $28.332 \times 2.947 = 83.4944$ calls and so on.

The results from fitting this model to the daily number of calls to Quitline are also plotted in figure 1 (dashed line). The fitted values fit the data well, following closely both the overall pattern and the fluctuations in total number of calls. Plot of residuals compared with fitted values and autocorrelation plot of the residuals (data not shown) show no model inadequacy. In figure 1 we also plot the non-parametric trend component (upper solid line). This component shows there are seasonal changes in the number of calls that are not related to the number of advertisements.

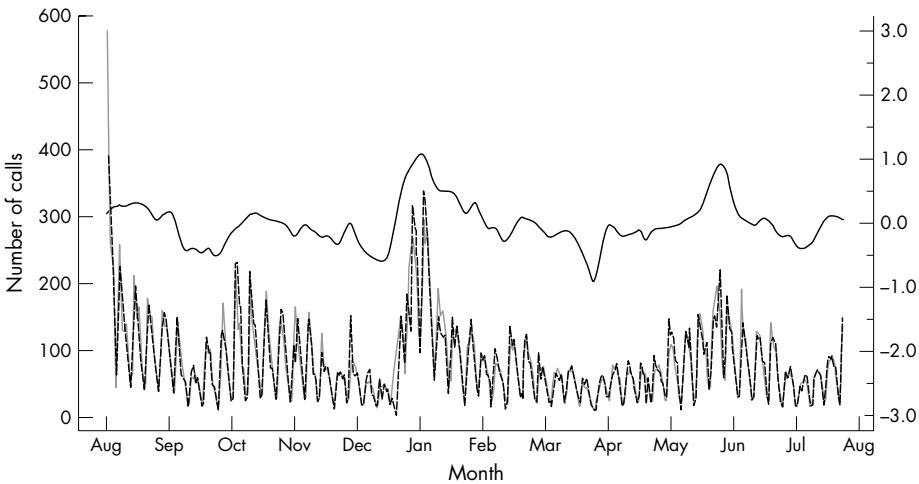

Figure 1 Daily total number of calls to Quitline (lower solid line) between August 2000 and July 2001. The fitted data (lower dashed line) represent a partial linear model with day, Quit advertisements, TARP and interaction between Sunday and total number of calls to Quitline as covariates in the model. The non-parametric component of the model is given in the upper solid line (not to scale).

What this paper adds

- This study is the first to show the utility of semiparametric models to model the relation between placement of antismoking advertisements on call volume to Quitline while taking into account the time series nature of the data.
- Our preliminary findings suggest that models with placement of Quit antismoking advertisements, TARPS (target audience rating points), and day of week effects adequately capture daily fluctuations in call volume for the study period.

Policy implications

- The predictive ability of these models would permit projections of total number of calls for a given time frame under different media buying strategies.
- Further detailed examination of the dynamics of call volume—that is, to include up to hour data—may have the potential to provide useful information for tobacco control campaign planners.

DISCUSSION

Semiparametric methods are useful for modelling the relation between outcome measures and covariates when the functional form of one or more covariates is unknown. This approach has captured the relation between daily total number of calls to the Quitline and placement of antismoking advertisements in programmes with different TARPS without explicitly modelling the variation over time. The results, from the parametric part of the model, show that day effects are strongly associated with total number of calls to Quitline Victoria, along with placement of Quit antismoking advertisements and TARPS generated by these advertisements.

Our emphasis has been on the parametric components relating to daily effects and the effects of advertisements. The non-parametric component gives insight into the underlying annual trend but may not truly represent the stochastic nature of the underlying process and there may be features that could be explained by the New Year holiday period for example. An alternate approach using varying coefficient models[13] would permit a more detailed examination of the dynamics of this process. The predictive ability of these models would permit projections of total number of calls for a given time frame under different media buying strategies. Furthermore, a modelling framework to include hourly data may have the potential to provide useful information for tobacco control campaign planners.

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