ORIGINAL ARTICLE

Time elapsed since the last medical visit: analysis of a statistical model applied to the case of Spanish women

Paulo Reis Mourão[1]

[1]Assistant Professor, University of Minho, Portugal

Summary

Objective: This study aims at two objectives: I) to develop a model capable of predicting the statistical distribution of the variable "time elapsed since the last medical visit"; II) to empirically test the theoretical model. **Methods:** To develop the theoretical model, the author will use a demonstration that is statistical in nature. In order to test the theoretical distribution, the 2006 *Encuesta Nacional de España* data regarding females will be used. **Results:** The results found show that the distribution of the time elapsed since the last medical visit follows a Poisson distribution. This conclusion was empirically validated, and additionally, a few determinants were found that increase the likelihood that Spanish women will resort to a doctor, namely, inactivity, residence in small places and being older. **Conclusion:** The study concluded that the time elapsed since the last medical visit follows a Poisson distribution; thus, going to a medical appointment is still seen as a rare phenomenon for Spanish women. By comparing this data with our results, we found that a higher ratio of physicians to population, a higher time availability for each woman (especially in a labor inactivity setting) and strong personal relationships can lead to a higher medical visit rate, thus reducing the time elapsed since the last visit.

Keywords: Medical referral and visit; Poisson distribution; Spanish Public Health.

From the Department of Economics, University of Minho, and Investigation Nucleus in Economic Politics, Portugal

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Correspondence to:
Paulo Reis Mourão
Campus de Gualtar – Universidade do Minho
Department of Economics
Economics & Management School
University of Minho
4700 Braga – Portugal
paulom@eeg.uminho.pt

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Introduction

Every individual make decisions about his personal health management as a function of several determinants. The set of determinants is not limited to personal factors, but a list of wider family and social factors is also involved.

One of the consequences of the interconnection all these factors is signaled by the frequency with which each individual resorts to medical care or to professional health support.

As a rule, individuals attentive to their health usally plan the medical visits within a certain period of time, e.g., over one year. In contrast, more irregular individuals either protract medical visits or schedule medical visits at very long intervals.

This study develops a model demonstrating why medical visits in a population follow a Poisson distribution. To do so, it uses official data collected from the 2006 report *Encuesta Nacional de Salud* about the female Spanish population.

In a review of the literature, different perceptions are found in males and females regarding personal, family or public health issues. Some of the papers demonstrating these varying perceptions include those from the Alan Guttmacher Institute[2], OECD[23] or Jones[20].

For example, as a rule, females usually spend more money on health goods and services than males. Contributing to an explaination of this phenomenon is the fact that females pay more attention to health issues than males, as well as certain cultural trends that assign a greater degree of vulnerability to females facing health issues.

On the other hand, females have less standardized behavior in accessing health goods and services. While males usually follow a routine of medical visits, e.g., with a time-outlined frequency, females are more receptive to advertising appeals, to official information about screening and/or prevention requirement, as well as to idiosyncratic factors leading to a more irregular visit schedule.

The literature in this the area is extensive. For example, the Andersen and Newman model[5] or the English Black report[11] are two references mentioned in the generic discussion about health services. Subsidiary papers, such as Aday and Andersen's[1] or Andersen's[6], try to update this framework based on three determinants of access to health services – the individuals' sociocultural characteristics, logistic characteristics (such as the individual income) and perception (self-perception and/or perception of others) of the need to resort to health services. Other documents[10] stress economic inequality as a cause for the inequality in access to health services.

Other papers support the need to address the social, individual and institutional characteristic complex to further understand the use of public health services, particularly in Ibero-Latin American realities. As examples of such papers, we cite Doval, Borracci, Darú, Giorgi and Samarelli[17], Albernaz and Victoria[3], Fernandez, Vasquez and Martinic[18], Bos[13] or Barata, Almeida, Monteiro e Silva[9].

There is still a wide group of authors studying the issue of visits to doctors and the determinants associated with them. For example, Boing *et al.*[12] observed that women, wealthy people, diabetics, smokers and former smokers, as well as alcoholics, resort to doctors more often. Diaz-Quimano *et al.*[16], in turn, recognized that weather changes (such as rainfalls) also influence the individual decision to see a doctor. Calderon-Ospina and Orozco-Diaz[14] studied adverse reactions to drugs as a reason to see a doctor. Araújo and Leitão[8], on the other hand, looked into explanatory reasons for the relative male aversion to see a doctor. Dias-da-Costa *et al.*[15], in turn, discussed the use of health services in a range of adults by using the observation of individual motivations. Sanchis-Bayarri *et al.*[26] explored the issue of how previous guided visits can be helpful in creating a behavior of more regular specialized medical visits.

However, the literature does not explore the issue of the interval between two medical visits. This paper aims to fill this gap, contributing to the debate by developing a theoretical model, adding an empirical test to the model.

Methods

Contribution to a model of time elapsed since the last medical visit

Our purpose was an abstract model that considered the time elapsed since the last medical visit, testing it by using appropriate statistical testing to observe which distribution characterizes this parameter, realizing the determinants that change the same distribution.

To model female behavior according to the number of times a female sees a doctor, the following model is presented. The indication *xi* refers to the time elapsed since a random female's last medical visit. Griffiths[19] and Alexander *et al.*[4] demonstrated that *xi* follows a binomial distribution, where *ni* indicates the number of observed individuals and *pi* is the probability of seeing a doctor:

xi~B(ni,pi)

For a large group of individuals, the time elapsed since the last medical visit is given by a Poisson distribution:

X~Poisson(np)

In this case, the product *n*p* is associated with the traditional parameter *lambda* in Poisson distribution. *n* refers to the individuals' group size and *p* is interpreted as the probability that all individuals in a given group or in a given category (e.g., in the same age group or in the same income level) will see the doctor. Thus, if *n* is fixed (e.g., considering all the categories have the same size or the sum of subcategories is 100%), we will conclude *lambda* will be increased as a function of *p*.

Next, the individuals' population is formally demonstrated as following a Poisson distribution.

This is the proof that a behavior model, in which an individual is characterized by a binomial distribution

$$Xi \sim B(ni,pi)$$

for a certain fixed period of time and by

$$X \sim Poisson(np)$$

for a population of individuals follows the traditional derivation of a Poisson distribution from the binomial distribution.

Thus, as recalled

$$B(ni,pi) = Probability\ (xi = k) = \binom{n}{k} p^k (1 - p)^{n-k}$$

In a Poisson distribution with an expected *lambda* [*Poisson(lambda)*], we have

$$P(X = k) = \frac{\lambda^{\kappa} e^{-\lambda}}{k!}$$

Our *lambda* is given either by the product *n*p*, that is,

$$\lambda = np$$

or, if we prefer, p = *lambda/n*

Thus, as n tends to infinity, the probability limit of the binomial distribution is

$$\lim_{n \to \infty} P(X_n = k) = \lim_{n \to \infty} \binom{n}{k} p^k (1 - p)^{n-k}$$

By deploying the equation, we have

$$\lim_{n \to \infty} P(X_n = k) = \lim_{n \to \infty} \frac{n!}{(n - k)!k!} \left(\frac{\lambda}{n}\right)^k \left(1 - \frac{\lambda}{n}\right)^{n-k}$$

As we know

$$\lim_{n \to \infty} \left(1 - \frac{\lambda}{n}\right)^n = e^{-\lambda}$$

And

$$\lim_{n \to \infty} \left(1 - \frac{\lambda}{n}\right)^{-k} = 1$$

Through a Stirling approximation for n tending to infinity,

$$Log(n!) \sim nlog(n) - n$$

leading to

$$\lim_{n \to \infty} \frac{n!}{(n - k)n^k} = 1$$

Therefore, we can conclude that

$$\lim_{n \to \infty} P(X_n = k) = \frac{\lambda^{\kappa} e^{-\lambda}}{k!}$$

Which was to be demonstrated.

Statistical analysis of the model

Data and sources

In order to find which social and economic dimensions are associated with a higher probability that the population will resort to doctors, this paper will use data from Spain, collected for the year 2006 from the *Encuesta Nacional de Salud de España* (available online at http://www.msc.es/estadEstudios/estadisticas/encuestaNacional/home.htm). This site is exceedingly detailed and enable us to ascertain the ethical standards observed in the *Encuesta*, as well as the methodological procedures used.

The *Encuesta Nacional* is the largest data base dealing with public health in Spain. The first issue was in 1987. However, the variable of time elapsed since the last medical visit (*Tiempo transcorrido dessde la ultima consulta médica*) was only detailed for several socioeconomical categories in the 2006 issue, allowing for a more accurate discussion about the dimensions that explain why certain individuals protract or pursue doctor's visits compared to individuals in other socioeconomic classes. Thus, the 2006 issue of *Encuesta Nacional* issue is the data source for our model empirical analysis.

The *Encuesta Nacional* study site was the Spanish territory and the population covered by the study was a group of 38,600 individuals interviewed between June 2006 and June 2007. The site mentioned the above details the various times, as well as the methodological procedures followed. For example, the interviews were conducted in two phases: in the first phase, there were generic household interviews; in a second phase, there were individual interviews. The sample was calculated considering place's representatitive proportionality in the national whole; the places of residence were classified into seven groups, from cities with less than ten thousand inhabitants to places with more than 500,000 inhabitants. This proportionality was later corrected by several estimators (detailed in the *Encuesta Nacional*) who considered the age cohorts and gender distribution. The information was mostly collected by a personal interview (and seldom by a telephone interview). Later, data was compiled in digital file systems in a format that enabled further statistical analysis using compatible software. Finally, both the results and the microdata were made available in three presentations: summaries, detailed results, and microdata files (all of these elements are also available at the electronic address above). In ethical terms, the individuals and their families were entitled not to answer the questions; they were contacted previously to get their agreement, and the *Encuesta* objectives, the predicted results, the potential publicizing means, as well as the final report formats were explained; thus, the sample only consisted of the families and the individuals who, following prior information, agreed to participate by means of their own free will.

Our variable values of interest (*Tiempo transcurrido desde la ultima consulta médica*) are the elapsed time within one of the ranges considered by the *Encuesta Nacional*, and are shown as a percentage for each category. The ranges were:

Range 1: below 15 days
Range 2: between 15 days and three months
Range 3: between three months and 12 months
Range 4: more than 12 months
Range 5: has never seen a doctor.

However, we considered the first four ranges as significant, since Range 5 ("has never seen a doctor"), according to the source, might be affected by significant measurement errors.

Given a distinct extent in each range, we resorted to a usual interval range centralization technique, using as central reference the natural logarithm of the median range value measured in the first period (15 days) unit. For example, the central reference for Range 2 was the natural logarithm of the median value corresponding to 2.7 fortnights, or therefore 0.99.

It must be remembered that the percentage sum per category makes up 100%. Thus, these values allow us to construct a probability density function. This probability density function associates each marked time range with the individuals in the observed sample category (e.g., it informs us about the percentage of individuals younger than 15 years who had seen a doctor over the last 15 days).

If we were asked *a priori* about the mean value for the time elapsed since the last medical visit per category, we would tend to "normalize" the distribution and we would calculate a weighted average. However, this result would have a bias if the distribution probability density function concerned were not a normal distribution. Thus, the most convenient procedure is to conduct as soon as possible an Anscombe Test[7], as soon as possible, the null hypothesis of which is "the probability density function tested does not characterize a Poisson distribution". This test is conducted per category for the respective probability density function.

In case the test rejects the null hypothesis, the variable has an observed value distribution following a Poisson distribution with a tendency to be associated with rare phenomena, such as the disease state frequency. Thus, if our tested variable (X, the time elapsed since the last medical visit) follows a Poisson distribution, this means the visits are a response to rare individual states, such as disease states (or disease perception states).

In case the test does not reject the null hypothesis, then the variable does not have an observed value distribution following a Poisson distribution. In this case, this would be the time to conduct the Normal Lilliefors tests (to assess for the presence of a normal distribution) or the Exponential Lilliefors tests (to assess for the presence of an exponential distribution).

If the probability density function is characterized as statistically close to the probability density function of a normal distribution, then the phenomenon of the time elapsed since the last medical visit would tend to be frequent. In our case, this means that there would be a time elapsed since the last medical visit, considered a central time and that the probability of the elapsed time to exceed this central time, for example, six months, would be equivalent to a case in which the elapsed time probability would fall six months short of that central time. This probability density function would follow the traditional sine graphic configuration.

In the other case (exponential distribution), we would face a phenomenon whose observation is concentrated within the first distribution classes. In this case, the probability density function would follow an exponential distribution, thus indicating that most observed cases would have a high visit frequency (e.g., every month), with few individuals having only one yearly visit.

Tests and results

Table 1 shows both the values for the expected *lambda* per female category studied in the 2006 *Encuesta Nacional* and the chi-square statistical value, which, from the Anscombe test[7] reading, allows the null hypothesis to be rejected in cases when the p value is higher than 10% (for a more detailed description, see Best[10]).

Data in Table 1 shows that all categories observed categories have associated *probability density functions,* allowing us to classify them as Poisson distribution.

As such, we can mark which categories have a higher probability of seeing a doctor in a given period of time. Therefore, we will focus on the expected *lambda*.

Considering the income categories, we observed that as the income level rises, the visit probability also rises. For example, the expected *lambda* (translating the $n*p$ product, that is, the product of the category dimension, which is considered fixed, by the probability to see the doctor) is 0.83 for the lower income category, while the expected *lambda* for the higher income category is 0.95.

The inactive female population (mostly girls and retired elderly females) also shows a higher probability of seeing a doctor than the female population considered active. The different *lambdas* are 1.16 (inactive population expected *lambda*) and 0.85 (active population expected *lambda*).

Table 1 – Statistical results

Categories	Subcategories	Estimated *lambda*	Chi-square	p-value
Women	Total	0.927	3.818	0.148
Income				
	1	0.83	2.37	0.31
	II	0.85	2.69	0.26
	III	0.93	3.09	0.21
	IV-a	0.96	3.58	0.17
	IV-b	0.95	3.64	0.16
Occupation				
	Active	0.85	3.47	0.18
	Inactive	1.16	4.53	0.104
Education				
	High school	0.84	2.62	0.27
	University	0.85	2.69	0.26
Hometown				
	[0; 2.000]	1.00	2.56	0.28
	[2.000 to 50.000]	0.96	4.42	0.11
	[50.000 to 100.0000	0.89	3.21	0.20
	[100.000 to 1 million]	0.93	2.51	0.29
	[> 1 million]	0.87	3.88	0.14
Age				
	< 15 years	0.77	3.55	0.17
	15 to 34 years	0.77	3.86	0.15
	35 to 44 years	0.79	3.51	0.17
	45 to 64 years	1.23	1.83	0.40
	≥ 65 years	1.66	3.01	0.22

Source: Author data on *Encuesta Nacional de Salud de España* (2006).

Regarding education, the *lambdas* in the two categories considered do not have significant differences. In this case, the expected *lambda* for the high school education population is 0.84; a population with university education is characterized by an expected *lambda* of 0.85; thus, we can infer that there will be a higher trend towards visiting a doctor in a population with a university education level.

By looking at the respondents' hometown, we can observe the *lambda* is higher in those living in small places (the expected *lambda* is 1.00). This value could be explained by the proximity between medical service providers and the female population users. In contrast, in a large city (for example, a population higher than one million inhabitants), the *lambda* is lower (0.87), indicating that, for the same population ratio (the probability oscillation was assessed by a fixed *n*), the probability of resorting to a doctor is lower. In this case, the transportation and waiting cost (significantly higher in a large city) will weigh in, reducing the probability of visiting the doctor where there is a larger population.

Finally, regarding age groups, as Spanish women grow older, there is a trend towards an increased probability of going to medical appointments. The reason for this could be not only be the higher probability of a disease, but also the greater personal experience accumulated, which leads to her resorting to a doctor when she anticipates signs of health problems.

In summary, our results demonstrate that the following factors provide a higher probability that Spanish females will resort to a doctor were as follows:

– higher income;
– belonging to an inactive population group;
– living in smaller places;
– belonging to an older age group.

Discussion, conclusions and implications

This study reviewed the time elapsed since the last medical visit using two approaches.

The first approach was theoretical and the second one was empirical; both used the *Encuesta Nacional de Salud de España*, edition 2006, and particularly data belonging to the approach *Tiempo transcurrido desde la ultima consulta medica*, were used as a database.

The first approach confirmed, the hypothesis that the time elapsed since the last medical visit tends to follow a function of Poisson distribution, traditionally associated with *rare events*. Thus, the distribution of the time elapsed since the last medical visit shows that most of the studied individuals (in this case, Spanish women) see the medical visits as a response to a disease state. This approach thus confirms the conclusions by Martins *et al.*[22]; they have also detailed the phenomenon of females resorting to medical appointments by females.

The second approach focused on the distribution and expected *lambda* reading for each category. We realized which categories have a higher probability of resorting to a doctor over a certain period of time. These categories are characterized by a higher income level, by inactivity by living in smaller places and by being in an older age group.

These results, confirming the conclusions by Lacerda *et al.*[21] or by Rodrigues *et al.*[25] about other population samples, bear three relevant implications.

Firstly, they prove that, for the sample studied, going to see a doctor is viewed mostly as a reactive behavior (reaction to the disease), rather than as a preventive behavior (this would be denoted by different distributions with a normal tendency).

Secondly, by observing the categories in which the probability of resorting to a doctor is maximized we can suggest various qualities required to optimize this option: an increased income, a longer time available to self-realize health problems (as the case of the inactive population), as well as experience with the symptoms (this is the case of the older age group).

Lastly, as the sample categories tend to converge around the indicated qualities (for example, economic development or population ageing), this study recommends an appropriate response on the part of training health professionals in order to narrow health service delivery towards the neediest population in the future, and, in accordance with Rios and Vieira[24], suggests that the medical appointment time be used as an opportunity for public health education.

Finally, as a challenge, the "age" variable control requirement should also be analyzed using multiple regression technique, or through stratification techniques so that the results discussed here are depurated; however, these results have already been relevant to decision-making in the management of public health services.

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