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Disclaimer

This article presents independent research. The views expressed are those of the authors and not necessarily those of the Carlos III Institute of Health.
Abstract

Purpose: This study analyzes whether there are time patterns in different intimate partner violence (IPV) indicators and aims to obtain models that can predict the behavior of these time series.

Methods: Univariate autoregressive moving average models (ARMA) were used to analyze the time series corresponding to the number of daily calls to the 016 telephone IPV help line and the number of daily police reports filed in the Community of Madrid during the period 2008-2015. Predictions were made for both dependent variables for 2016.

Results: The daily number of calls to the 016 telephone IPV help line decreased during January 2008-April 2012 and increased during April 2012–December 2015. No statistically significant change was observed in the trend of the number of daily IPV police reports. The number of IPV police reports filed increased on weekends and on Christmas holidays. The number of calls to the 016 IPV help line increased on Mondays. Using data from 2008-2015, the univariate ARMA models predicted 64.2% of calls to the 016 telephone IPV help line and 73.2% of police reports filed during 2016 in the Community of Madrid.

Conclusions: Our results suggest the need for an increase in police and judicial resources on non-work days. Also, the 016 telephone IPV help line should be especially active on work days.

Key words: Intimate partner violence, battered woman, spatial temporal analysis, Spain
List of abbreviations

IPV: Intimate partner violence against women

ARMA: autoregressive moving average models

AR: auto-regressive

MA: moving average
Introduction

Intimate partner violence against women (IPV) is a public health problem that negatively affects quality of life for women, families and for society [1]. The European Institute for Gender Equality estimates the cost of IPV in the European Union at 109.1 billion Euros [2]. Studies have identified individual, relational, community and structural risk factors that can increase women’s vulnerability to IPV [3,4]. The study of seasonal cycles that accompany IPV episodes could provide useful information to predict periods of change in women’s risk. Preventive measures, such as intensifying surveillance of women at high risk of aggression or reducing women’s contact with the aggressor during high risk periods could reduce the likelihood of aggression.

Studies [5,6] have identified an increase in assaults and rapes during the hottest times of the year (June–September); in contrast, homicides did not show any seasonal pattern [6]. Recent study describe a temporal pattern in violent crimes -homicides, rapes, aggravated assaults, and robberies-, showing that violence increases in the hottest months and with abnormally high temperatures, especially when these temperatures occur during the winter months. This association is significantly greater in lower income neighborhoods [7]. Changes in alcohol consumption patterns [8,9], and changes in times in which victim and aggressor coincide- The Routine Activity Model Approach- are possible hypotheses [10,11].

There are few studies that have identified possible temporal patterns in IPV. Results from Michel and Zumpe [6] showed increases in the number of crisis telephone calls, requests for shelter and number of women given shelter during the summer months. These increases were significantly related to temperature rhythms. According to the General Affective Aggression Model (GAAM), high temperatures cause human irritability, may trigger irritation and discomfort and thereby heighten aggression [12]. It is possible also that, since a Routine Activity Theory approach, high temperature increased cohabitation with a partner, and this may increase the probability of conflict and aggression [11]. Studies in New Jersey [13] found no space-time cluster in IPV homicides. In Spain Vives et. al found that a woman’s risk of
femicide increased 77% on Monday [14]. Different IPV indicators may show different
dynamics.

In Spain, the Organic Law 1/2004 on Integral Protection Measures against Gender
Violence [15] spurred police and judicial protection for women exposed to IPV, including the
adoption of the 016 telephone IPV help line, which provides information, referral and legal
advice related to IPV [16].

The daily frequency of IPV help line telephone calls, as a reflection of IPV exposure,
and frequency of police reports filed, as a proxy for demand for help, are indicators that may
permit identifying possible temporal patterns in IPV. Time series analysis using autoregressive
integrated moving average models (ARIMA) [17] is useful in the study of the behavior of public
health indicators, both from a predictive and a diagnostic perspective [18-21]. We
hypothesized that IPV may show a temporal pattern. It is possible that IPV increases during
hottest months, and when cohabitation is greater. Knowledge of the dynamics of different
indicators of IPV could help support effective use of IPV resources.

The objective of this study was twofold: 1) to analyze whether there are temporal
patterns in the number of daily complaints of IPV and in the daily number of 016 telephone
calls and 2) to obtain prognostic models to predict the behavior of these series for a relatively
lengthy time period, such as an entire year.
Methods

Data sources and dependent variables

- Number of daily calls to the 016 telephone IPV help line carried out in the Community of Madrid during the 2008-2016 period. Data was provided by the Government Office for Gender Violence (Ministry of Health, Social Services and Equality).
- Number of daily police reports filed with the state police force (FCSE; National Police Force and Civil Guard) in the Community of Madrid during the 2008-2016 period, provided by the Criminal Statistics System (Secretary of Security of the Ministry of the Interior).

Statistical analysis

The number of daily calls to the 016 telephone IPV help line and the number of daily IPV police reports filed were analyzed using univariate auto-regressive (AR) integrated (I) moving average (MA) ARIMA models. The models are based solely on the history of the series; they do not include external variables not inherent in the series structure (trends, cycle, and seasonal variables).

The ARIMA forecasting equation for time series is a linear equation in which the predictors consist of lags of the dependent variable and/or lags of the forecast errors. Thus:

Predicted value of $Y = a$ constant ($\mu$) and/or a weighted sum of one or more recent values of $Y$ ( $Y_{t-1}$...$Y_{t-p}$) and/or a weighted sum of one or more recent values of the errors ( $e_{t-1}$...$e_{t-q}$).

A nonseasonal ARIMA model is classified as an "ARIMA (p,d,q)" model, where:
- $p$ is the number of autoregressive terms,
- $d$ is the number of nonseasonal differences needed for stationarity, and
- $q$ is the number of lagged forecast errors in the prediction equation.

In terms of $y$, the general forecasting equation is:
\[ \hat{y}_t = \mu + \phi_1 y_{t-1} + \ldots + \phi_p y_{t-p} - \theta_1 e_{t-1} - \theta_q e_{t-q} \]

In the case of a model with seasonality \( S \) of the form \( (P,D,Q) \) the equation would be similar to the above mentioned equation, but taking into account that the lags \( P \) and \( Q \) refer to seasonal periods. This work uses a seasonal period of 7 days, therefore the terms \( P \) and \( Q \) would refer to the values of “\( Y \)” and “\( e \)” that have occurred \( 7*P \) and \( 7*Q \) days later, respectively.

To control the differencing component \((I)\) has been introduced a trend component (counter named \( n_1 \)). The trend is included through a counter \( n_1 \) which would be equal to 1 for the first day of the series, 2 for the second, and successively. By this procedure ARIMA models change to ARMA models during the following steps.

To control for annual (365 days), semestral (180 days), trimestral (90 days), and bi-semestral (60 days) seasonality, the functions sine \((\sin)\) and cosine \((\cos)\) were included in these periodicities in the following way: \( \sin_{365} = \sin \left(2 \times 3.1416 \times n_1 / 365\right) \) and \( \cos_{365} = \cos \left(2 \times 3.1416 \times n_1 / 365\right) \).

Vacation periods and days of the week are included as dummy variables. The corresponding vacation periods were: Christmas Holidays from December 24th through January 6th, Summer Holidays from July 1st through August 31st, and the Easter Holiday which varies each year.

Modelling is a step by step process with the elimination of those variables with an insignificant estimator at \( p<0.05 \). The model’s goodness of fit was obtained by analysis of residuals, by obtaining the Akaike Information Criterion \((AIC)\), Bayesian information criterion, autocorrelation function, partial autocorrelation function and Ljung-Box test. We use \( p<0.05 \) as the criteria to select the final statically significant variables, and during the process it is possible to obtain different final models (or versions), that can include different variables, due to the high correlation between similar variables, for example, variables to control seasonalities. The Autocorrelation Function \((ACF)\) and Partial autocorrelation function \((PAF)\)
are supposed to have white noise in the final models considered. To select the best model between the possible final models, we used the AIC.

The modelling process of dependent series variables was carried out for the 2008-2015 period. The resulting model was applied to the prediction of the values of the dependent variables for the year 2016. The fit of prediction between the adjusted and real values was carried out using Pearson’s correlation. The sensitivity of the coefficients was found using the Jack-Kniffe method. The statistical software package used was SPSS v15.

Results

Time series evolution and modelling of the variable “daily IPV police reports filed”

During the 2008-2016 period, there were 84,652 IPV police reports in the Community of Madrid, an average of 25.7 per day (standard error 8.7). Figure 1 shows the temporal evolution of the variable “IPV police reports filed” during the 2008-2015 period. The significant variables found in the univariate modeling process are shown in Table 1. During 2008-2015 there was no statistically significant change in the trend of the daily number of IPV reports. Police reports that occur on a day “t” are associated with reports filed the prior day with a coefficient (AR1:0.99), and with reports filed the prior week as shown by the coefficient for the seasonal period of 7 days introduced in the model (seasonal AR1:0.62). During Christmas Holidays the number of daily IPV police reports filed increased significantly (Christmas Holidays: 4.84), as it did on the weekend- and Friday and Monday-, with the greatest number of reports filed on Sunday (Sunday: 12.40). Therefore, IPV reports filed produced on day “t” respond to the following equation given by the model:

\[ n_t = \text{Police reports}_t - (0.62 \times \text{Reports}_t - 2.46 \times \cos365 + 3.87 \times \text{Monday} + 22.3) \]

\[ n_t = 0.99 \times n_{t-1} + 0.92 \times \text{error}_{t-1} + 0.07 \times \text{error}_{t-2} + 0.62 \times n_{t-7} + 0.55 \times \text{error}_{t-7} \]

The day of the week will include in the equation if day of t = name of the day of the week.
Figure 1a shows the sequence graph of the predicted and real values of the variable “daily IPV police reports filed”. The Pearson’s correlation coefficient between both series is 0.575, significant at p<0.001 for the 2,922 data points of the time series from 2008 to 2015.

The model’s goodness of fit, obtained by the simple autocorrelation function of the error, shows that the error structure in the different lags is random, indicating a good fit of the model.

Figure 2a shows the comparison between the prediction of the number of daily police reports in 2016, based on the model identified with the analysis of the data from 2008 to 2015, with the number of real reports registered in 2016. The Pearson correlation among the predicted and real values is 0.642, which is significant at p<0.001 for the 366 data points of the fit.

Temporal evolution and modeling of the variable “daily calls to 016 telephone IPV help line”.

During 2008-2016 there were 143,863 calls to the 016 telephone IPV help line in the Autonomous Community of Madrid. Figure 1b and 1c show the temporal evolution of the variable “daily calls to 016 telephone IPV help line” during the 2008-2015 period. The time series of this variable behaves in a “V” fashion, indicating a change in the behavior trend of the time series. After adjusting to a quadratic function, it is significant at p<0.001 with a Snedecor F of 257.92 and an equation: “daily calls to 016 telephone IPV help line”=7.6*10^-6n^2-0.024n+55.7. The determination of the minimum point of the parabola according to the previous equation indicates that this trend change occurs for n=1564, which corresponds to April 12, 2012. This different temporal behavior justifies the analysis of the series in two periods.

During period 1, which includes the time between January 1st, 2008 and April 12th, 2012 (n<1564), there is a statistically significant decreasing trend in the number of daily calls to the
016 telephone IPV help line. The average number of calls during this period was 44.5 calls per day. During period 2, which includes the time period from April 13th, 2012 to December 31st, 2015, the trend becomes increasing, with statistical significance. In this period, the average number of calls to 016 is 40.8 calls per day.

The coefficients of the significant variables after the univariate modeling of the variable “number of daily calls to 016 telephone IPV help line” in period 1 and period 2 are shown in Table 2. In both periods, calls that occur on day “t” are associated with the calls of the three prior days, in both period 1 (AR1: -0.88; AR2: 0.44; AR3:0.32) and period 2 (AR1: 1.62; AR2:-1.28; AR3:0.61) and with the calls from the prior week (P1: seasonal AR1: 0.94; P2: seasonal AR1: 0.93) (P1: seasonal AR1: 0.94; P2: seasonal AR1: 0.93). The number of 016 telephone IPV calls decreases during the days of the weekend and the day prior day, which is Friday. Saturday is a day with low telephone IPV demand in both periods (P1 Saturday:-7.56; P2 Saturday: -8.31), and Monday is the day that accounts for the greatest number of calls (P1 Monday: 9.55; P2 Monday: 7.64). The prediction equation for day “t” based on these coefficients is expressed for period 1 in the following way:

\[ n_t = ( \text{Telephone 016 IPV Calls}_t - (-0.94* \text{Calls}_{t-7} - 0.95* \text{error}_{t-7} -0.01n1 + 9.55 * \text{Monday} + 2.97 * \text{Tuesday} + +3.02*\text{Friday} -7.56* \text{Saturday} -5.57* \text{Sunday} - 51.06) \]

And for period 2:

\[ n_t = ( \text{Telephone 016 IPV Calls}_t - (0.93* \text{Calls}_{t-7} + 0.91* \text{error}_{t-7} + 0.01n1 + 7.64* \text{Monday} + 1.98*\text{Tuesday} -8.31* \text{Saturday} -6.54* \text{Sunday} -5.21 *\text{Easter Holidays} + 4.39) \]

\[ n_t = 1.62*n_{t-1} -1.28*n_{t-2} + 0.61*n_{t-3} +1.38*\text{error}_{t-1} - 1.07* \text{error}_{t-2} + 0.47* \text{error}_{t-3} + 0.93*n_{t-7} + 0.91* \text{error}_{t-7} \]
Figure 1b and 1c show the real and predicted values of the temporal evolution of the series of daily calls during the 2008-2015. The coefficient of Pearson’s bivariate correlation among both series for period 1 is 0.601 (p<0.001) for the 1564 data points of the time series and 0.717 (p<0.001) for the 1358 data points of the series for period 2.

The simple autocorrelation function of the error shows that the error structure in the different lags is random, indicating a good fit of the model.

Finally, if the ARMA model obtained for the variable telephone 016 IPV calls during period 2 is used to predict behavior during the year 2016, the result shown in Figure 2b is obtained. Pearson’s bivariate correlation coefficient for both series is 0.732 (p<0.001) for the total of 365 predicted days.
Discussion

Main results

During the 2008-2016 period there were nearly 26 IPV police reports filed per day, and an average of 44 daily calls made to the 016 telephone IPV help line in the Community of Madrid. During the 2008-2015 period, there was no statistically significant change in the trend of the number of daily IPV police reports. The probability of filing an IPV report increased during the Christmas Holiday period. Sundays were the day with the greatest number of reports filed, followed by Saturday and Friday.

The daily number of calls to the 016 telephone IPV help line decreased significantly in a first period (January 2008/April 2012) to continue with an increasing trend in a second period (April 2012/December 2015). In both periods, during the Easter Holiday period the probability of making a call to 016 decreased. Saturday was the day with the lowest number of calls to the 016 telephone IPV help line, followed by Sunday and Friday.

The equations identified through ARMA models using data from 2008-2015, the univariate ARMA models predicted 64.2% of calls to the 016 telephone IPV help line and 73.2% of police reports filed during 2016 in the Community of Madrid.

Possible explanations

The absence of a significant trend in daily police reports during the period studied could be due to the stable prevalence of IPV over time and/or to the stability of factors related to greater probability of filing a report. According to the Macrosurvey on Gender Violence, the prevalence of women who have ever suffered IPV in Spain presents little variation during the 2011-2015 period (10.9% vs 13%) [22,23]. Recent studies show that fear and lack of confidence in the police processes is one of the reasons that women give for not filing a report [24]. Our
resultados sugieren la necesidad de identificar acciones que eviten el recidivismo de los agresores y aumenten la confianza de las mujeres en el proceso policial.

La mayor cantidad de llamadas al servicio de ayuda telefónica 016 de violencia interpersonal (IPV) se registró en 2008, posiblemente asociado con un aumento en las actividades de sensibilización para 016 en 2007. El decrecimiento en el número de llamadas durante el periodo 2008-2012, seguido por un incremento en el siguiente periodo, se observa también en otros indicadores relacionados con IPV. Durante el periodo 2008-2015, el número de femicidios y divorcios -que representan un riesgo para IPV- alcanzaron sus niveles más bajos en 2012 y 2013, respectivamente [25]. Además, la crisis económica de España, que comenzó en 2008, podría haber dificultado las separaciones y divorcios de parejas, lo que resultó en una disminución en la demanda de 016 [27,28]. La implementación, durante el segundo periodo, de campañas de sensibilización relacionadas con llamadas al servicio telefónico de 016 dirigidas a grupos vulnerables [29,30] podría estar asociada con el incremento en el número de llamadas.

Nuestros resultados podrían explicarse utilizando el marco de la Teoría de la Actividad Routine [11]. La probabilidad de presentar una denuncia de IPV ante la policía se relaciona con periodos caracterizados por mayor oportunidad de conflicto, que incluyen periodos no laborales, con el domingo como el día de la semana con la mayor probabilidad de presentar una denuncia ante la policía, y el periodo de vacaciones de Navidad.

Eso dice que las denuncias ante la policía se presentan principalmente en periodos no laborales podría indicar que la presentación de una denuncia ante la policía no es un comportamiento planeado, sino que ocurre cuando la violencia supera un cierto nivel de gravedad, en el que una mujer busca protección externa [30-32]. Los recursos y medidas de vigilancia para las mujeres en riesgo alto deben aumentar en días no laborales, y las mujeres deben tener oportunidades de pasar tiempo fuera de casa durante periodos de alto riesgo, reduciendo las oportunidades de agresión.

Llamadas a la línea de ayuda telefónica 016 de IPV se comportan inversamente y disminuyen durante periodos no laborales, fines de semana, y el periodo de festividad de Pascua, y aumentan en los días posteriores a estos periodos. Esto nos da información importante sobre el uso de los recursos. Eso sugiere que en casos de IPV el demanda de información y asistencia telefónica IPV es un comportamiento planeado.
permits being delayed until a woman can find a space to call without the presence of the aggressor.

This study has some limitations. The observational longitudinal time series design uses aggregated data, which prevents individual level conclusions. Second, only one in three women exposed to IPV filed a police report [23], therefore women that file a police report are not representative of all women exposed to IPV. And finally, the analysis of the number of daily calls to the 016 telephone IPV help line could include repeat calls from a single woman.

Despite these limitations, the models identified in this study have a high predictive value for the behavior of reports and calls during the year 2016. Including time variables in protocols that estimate the risk of women under surveillance for experiencing IPV could increase their efficiency. Our results suggest the need for an increase in police resources on non-work days, given that the probability of reports on these days is greater. In the same way, the 016 telephone IPV help line should be especially active on work days. The ARIMA method is useful from the diagnostic and predictive points of view, however, including other external variables could increase the fit of the predictions and support the effort to address IPV.

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Conflicts of interest

None declared


Ley Orgánica de Medidas de Protección Integral contra la Violencia de Género L N° 1/2004 (28 de diciembre 2004.)


Ministry of Health, Social Services and Equality. Government Delegation for Gender Violence, Spain


Figure 1.

a) Real values and estimated values of the number of daily police IPV reports from January 1st, 2008 to December 31st, 2015.

b) Real values and estimated values of the number of daily calls to the 016 telephone IPV help line from January 1st, 2008 to April 12th, 2012.

c) Real values and estimated values of the number of daily calls to the 016 telephone IPV help line from April 13th, 2012 to December 31st, 2015. Autonomous Community of Madrid.
Figure 2:

a) Real value and prediction of the number of daily police reports of IPV
b) Real value and prediction of the number of daily calls to the 016 telephone IPV help line. Period from January 1st, 2016 to December 31st, 2016. Autonomous Community of Madrid.
### Table 1. Univariate models of the variable “daily police reports of IPV filed in the Community of Madrid. 2008-2015 Period.

<table>
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<th>Estimates</th>
<th>Standard error</th>
<th>p</th>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>0.993</td>
<td>0.007</td>
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<td>0.918</td>
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<td>MA2</td>
<td>0.065</td>
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<tr>
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<tr>
<td>sine 365</td>
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<td>cosine 60</td>
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<td>Monday</td>
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AR: autoregressive term; MA: moving average terms
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</tr>
<tr>
<td>n1</td>
<td>-0.008</td>
<td>0.001</td>
<td>&lt;0.001</td>
<td>0.017</td>
<td>0.003</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Monday</td>
<td>9.549</td>
<td>0.726</td>
<td>&lt;0.001</td>
<td>7.641</td>
<td>1.074</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Tuesday</td>
<td>2.966</td>
<td>0.718</td>
<td>&lt;0.001</td>
<td>1.984</td>
<td>1.005</td>
<td>0.049</td>
</tr>
<tr>
<td>Friday</td>
<td>-3.017</td>
<td>0.719</td>
<td>&lt;0.001</td>
<td>-1.587</td>
<td>1.007</td>
<td>0.115</td>
</tr>
<tr>
<td>Saturday</td>
<td>-7.557</td>
<td>0.726</td>
<td>&lt;0.001</td>
<td>-8.308</td>
<td>1.074</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sunday</td>
<td>-5.560</td>
<td>0.768</td>
<td>&lt;0.001</td>
<td>-6.553</td>
<td>1.105</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Easter holidays</td>
<td>-3.903</td>
<td>2.202</td>
<td>0.076</td>
<td>-5.208</td>
<td>2.705</td>
<td>0.054</td>
</tr>
<tr>
<td>Constant</td>
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<td>0.880</td>
<td>&lt;0.001</td>
<td>4.391</td>
<td>6.939</td>
<td>0.527</td>
</tr>
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</table>

AR: autoregressive term; MA: moving average terms

Table 2. Significant variables in the univariate models of the variable daily calls to the 016 telephone IPV help line in the Community of Madrid during Period 1 (January 1st, 2008 through April 12th, 2012) and during Period 2 (April 13th, 2012 through December 31st, 2015)
Highlights

• It is unknown whether IPV responds to cycles that permit prediction of periods in which a woman could be at increased risk of suffering aggression.

• The time series analysis of the number of daily calls to the 016 help line, as well as the daily number of reports filed, could help to predict possible periods of risk.

• The findings of this work show that IPV reports increase during the Christmas Holidays and on weekends. Calls to the 016 help line decrease during the Easter Holidays and on non-work days and increase on Mondays.

• Our results suggest the need to increase police and judicial resources on non-work days. 016 help line assistance should be especially active on work days.

• Univariate ARIMA modeling used in this model could be useful regarding IPV from both a diagnostic and a prognostic point of view.