Does better access to primary care reduce utilization of hospital accident and emergency departments? A time-series analysis

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Background: Availability of primary care emergency facilities has been improved to help curb heavy growth in the use of Accident and Emergency Departments (A&EDs). The aim of this paper is to analyse the relationship between time series for visits to hospital A&EDs and primary care centres. Methods: Using a co-integration time series we analyse the visits to the emergency services of the county hospital and seven healthcare primary centres in the healthcare district of Mieres, Asturias, Spain, during the period 1992–1999. The main outcome measured is the relationship between the time series for emergency visits to the primary care centres and the hospital A&ED, for groups aged 0–14 years, over 14 years and the total. Results: A total of 506 158 visits to the emergency services of the primary care centres (62.4%) and hospital A&ED (37.6%) have been studied. Emergency visits rose by 40.9% during the period studied (50.3% in primary care centres and 26.5% in the hospital). The gross rise in visits was higher for adults (51.2%) than for 0–14 year olds (6.6%). The co-integration time-series analysis showed that in both age groups and in the total, there was a significant and positive relationship between the primary care and hospital series, indicating that the use of both services had grown simultaneously. The use of the hospital services did not decrease as a result of the increase in primary care services. Conclusions: The rise in use of primary care emergency services did not reduce use of the hospital A&ED.

Materials and methods

An analysis was made of all the emergency consultations in the healthcare district of Mieres, in Asturias, Spain, between 1992 and 1999, in both primary care centres with on-going services and the A&ED at the reference hospital. All these units form part of the public health system, which gives free assistance to the whole population. (In this healthcare district there is no private assistance service).

This district provides healthcare to 82,993 inhabitants, of whom 11.7% are under the age of 14 years. Over the last few decades, the district’s industrial sector has undergone deep restructuring, and the area has lost close to 20% of its population. The remaining population is aging rapidly, and in 1995 birth and mortality rates were 5 and 10.8%, respectively. The area has one public hospital with an A&ED, six primary care centres with on-going services, and an Emergency Service at the area’s healthcare headquarters. The on-going services at the primary care centres opened in 1986 and 1989 and are staffed by doctors and nurses from the primary care centres themselves. These services are open from 15:00 to 22:00, with the exception of one centre, which is open from 15:00 to 8:00. The A&ED is organized according to a model designed prior to the creation of the on-going service units at the primary care centres; it is open from 17:00 to 8:00 and is manned by its own staff, which is independent from the personnel at the primary healthcare centres.

The data on emergency visits are collected when the patient comes to the A&ED. These data include age, gender, address, emergency visit date and hour, final decision (transferring home or to another health centre, admission, exitus), origin of the visit...
(spontaneous or derived from another healthcare service), in the case of hospital A&EDs since visits to primary care centres A&EDs are always spontaneous, and non-codified diagnosis. In the case of hospital and since 1992 we have individual computerized data, but in the case of primary care centres the data are monthly aggregates, distinguishing between 0–14 years and over 14 years visits.

Using data provided by the Hospital Admissions Service and the district’s Directorate for Primary Care, the monthly series reflecting the visits to the A&ED and the on-going emergency services at the primary care centres were constructed for the time period between 1992 and 1999 (96 months), for two age groups (0–14 years and over 14 years) and for total visits.

A descriptive analysis of the annual evolution of the gross number of visits was made, followed by an evaluation of the influence of the longer hours at the primary care centres on the use of the hospital A&ED. A co-integration time-series analysis was then performed to establish the relationship between the series for the use of the A&ED and for the on-going primary care services. The co-integration analysis is a relatively recent econometric tool used to estimate stable or long-run relationships between two or more variables using time-series data. When doing an econometric analysis of time-series data, it is important for the time-series variables to be stationary. A time-series process is said to be stationary if the means and variances of the actual time at which this co-variance is considered. If one or more of these conditions are not fulfilled, the process is non-stationary. Non-stationarity is generally regarded as problematic in econometric analysis, since the statistical properties of a regression analysis using non-stationary time series are dubious. In fact, if the series is non-stationary, the probable result is a problem of spurious relationships: a model showing promising diagnostic test statistics, even in the case where no sense can be made of the regression analysis.

A co-integration analysis can be made stationary by using first differences rather than the levels of the variables. Sometimes it is necessary to difference a series more than once to achieve stationarity. A co-integration time-series that can be transformed into a stationary series by differencing \( d \) times is said to be integrated of order \( d \), denoted by \( X_t \sim I(d) \). The basic idea of co-integration is that even though each of the two, or more, variables may be non-stationary, a linear combination of them may have the stochastic trend term mutually cancelled out so that it becomes stationary thus making the series stationary. This linear combination is known as a co-integrating vector or co-integrating relationship. Before proceeding with the co-integration analysis, it is necessary to verify whether the variables under consideration are stationary, and, if they are not, their orders of integration must be checked. The so-called unit root test can be used to do this, because a variable is non-stationary if it has a unit root.

We considered testing for multiple unit roots in monthly seasonally unadjusted time series. This is more complicated than considering the possibility of a unit root in the non-seasonal variables at the zero frequency, since 12 different unit roots are possible in a monthly seasonal process. In this case, a non-stationary series is said to be seasonally integrated of order \((d, D)\), denoted \(S_{I(d,D)}\) if it can be transformed into a stationary series by applying 12 differences \( D \) times and then differencing the resulting series \( d \) times using the first differences (Appendix A shows more details about these tests). We prefer using these series to using their seasonally adjusted counterparts, since the usual filters employed to adjust for seasonal patterns (for example, the linear Census X-11 method) often distort the underlying properties of the data. The analysis was performed using logarithmic transformed variables, in order to make the series linear and to dampen the variances.

After analysing the stationarity and the co-integration of the series, we applied the method described by Hylleberg et al. to establish appropriate filters to remove the seasonal roots indicated by the above tests (see Appendix A) and then applied the standard co-integration tests. The method we used to detect the existence of co-integration between the series is based on the contrast described by Engle and Granger, who applied the augmented Dickey–Fuller test, complemented with Johansen’s maximum likelihood procedure, which has gained a lot of popularity in recent applied literature. Our approach, in this case, uses the trace statistics for the number of co-integration vectors, together with a small sample adjustment, as suggested by Reimers. The stationarity tests and the other regression analyses presented in this work have been conducted using the Eviews econometric software package (version 3).

**Results**

In the period between 1992 and 1999, the total number of emergency visits made was 506 158; 62.4% corresponded to the primary care centres and 37.6% to the hospital A&ED.

![Figure 1](image-url) Changes in visits to emergency services in the healthcare district of Mieres, 1992–1999
More men than women consulted at the A&ED (54.4 and 45.6%, respectively); 71.9% of the consultations were spontaneous (with no referral from the primary care doctor); two-thirds of the total attenders were from the hospital’s immediate surroundings; 20% required admission. During the period under study, a drop in the number of visits requiring admission (−14.6%) and a rise in the number of spontaneous visits (13.4%) were observed.

During this period, a rise of 40.9% was observed in the total number of the emergency visits in the healthcare district. Visits to the primary care centres accounted for 50.3% of this increase, with a yearly rise of 7.3%, while visits to the hospital A&ED rose by 26.5%, with an average yearly increase of 3.4% (figure 1). A breakdown by age groups indicates that this growth was not evenly spread. Patients over the age of 14 years registered a 51.2% increase in emergency consultations (primary care: 63.1%; A&ED: 34.3%), compared with 6.6% in the group under the age of 14 (primary care: 12.5%; A&ED: −5.6%).

Figure 2 shows the time series for the total number of emergency visits, and for both age groups (0–14 and over 14 years of age), for consultations at the primary care centres and at the A&ED. A clear seasonal pattern can be seen, with the exception of the series for the 0–14 age group. Table 1 summarizes the unit root testing results using the approach described by Beaulieu and Miron. The series had unit roots at zero frequency but not at all the seasonal frequencies, that is, the variables were
SLT(1,0). This means that for the series corresponding to the A&ED, for the 0–14 years group, the over 14 years group, and the total, the data failed to reject unit roots at frequency $\pi/6$. However, for the series corresponding to the primary care centres, the 0–14 age group had unit roots at frequencies $\pi/3$ and $5\pi/6$, and the total number of visits had unit roots at frequencies $\pi/2$, $2\pi/3$, and $\pi/6$. Nevertheless, for the over 14 age group, the data rejected unit roots only at the $\pi/3$ frequency.

The results of the co-integration analysis (table 2) indicate that there is a co-integration relationship between the two series of emergency visits, in the 0–14 age group, the over 14 age group and in the total number of visits. This relationship is positive, as indicated by the $\beta$ coefficient in both types of contrasts, which indicates that the series for the emergency visits behaved identically, with a simultaneous increase in consultations at the primary care centres and at the A&ED. No trend was detected, which would indicate that the visits to the primary care centres replaced the visits to the A&ED in either of the age groups or in the total number of visits.

**Discussion**

The results of this study show that the number of emergency visits increased during the period analysed, both in the hospital and in the primary care centres although the increase was more pronounced in the latter. A co-integration analysis of the time series was used to evaluate whether the series behaved in the same way in the long term and to detect any trends in their behaviour. In the three series studied, we were able to establish that there is a long-term relationship between them, although we found no empirical evidence to support the idea that the emergency services provided at the primary care centres diverted visits from the hospital A&ED. These findings strongly suggest that both series are independent and that, assuming the remaining variables that affect users’ behaviour are equal, emergency services at the primary care level do not replace consultations at the hospital A&ED.

These results imply that the policy of reinforcing primary care emergency services, basically by expanding geographical accessibility and lengthening opening hours (and independently of whether these improvements constitute an objective in and of themselves, and of their impact on the use of hospital A&EDs), was not effective in lessening the load of the A&ED. Depending on the organizational models applied, this increase in accessibility may even have negative effects, such as a loss of continuity in the medical care provided if emergency services are covered by substitute doctors and not by the normal primary care physician. Other paradoxical situations may also be created, such as a rise in inappropriate use of both the primary care centres and the hospital A&ED.

The results of this study are consistent with findings from others conducted in Spain and elsewhere, which indicate that measures to improve the accessibility of emergency services at the primary care level (longer opening hours, increases in healthcare personnel and technical resources, assignment of primary care physicians to populations previously without this service, elimination of need for appointment, walk-in centres) have a minimum impact on diminishing the use of the hospital A&EDs. Other studies report decreases in the number of visits to the A&ED with the implementation of improvements in the accessibility of primary care emergency services. However, it is difficult to evaluate these findings for comparative purposes since these studies were conducted in the USA’s Medicaid programmes, a healthcare setting that is very different from countries with primary care systems, and because the time periods analysed were excessively short and did not detect general trends. One study reports a reduction of 6% in the use of the hospital A&ED after five primary care centres with on-going emergency services were opened in 1991; however, with the exception of the year under study, the use of the A&ED of that particular hospital showed an increase that was similar to the trend detected in hospitals overall.

**Table 1** Results of tests for seasonal unit roots in monthly series, 1992–1999

<table>
<thead>
<tr>
<th>Unit root corresponding to frequencies</th>
<th>A&amp;ED</th>
<th>Total</th>
<th>PC</th>
<th>Over 14 years</th>
<th>0–14 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>$\pi$</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>$\pi/2$</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>$2\pi/3$</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>$\pi/3$</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>$5\pi/6$</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>$\pi/6$</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: Yes = unit root, no = no unit root, A&ED: Hospital Accident and Emergency Department, PC: On-Going Primary Care

a: All series are in log levels

**Table 2** Co-integration test results at zero frequency for seasonal unit root filtered series

**Engle–Granger co-integration results (ADF)**

<table>
<thead>
<tr>
<th>Long-run relationship: $X_{A&amp;ED,t} = \text{Constant} + \beta X_{PC,t} + \mu_t$</th>
<th>0–14 years</th>
<th>&gt; 4 years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A&amp;ED$</td>
<td>$-0.005 + 0.2566$ PC</td>
<td>$0.0045 + 0.00371$ PC</td>
<td>$0.0087 + 0.00029$ PC</td>
</tr>
<tr>
<td>$ADF$</td>
<td>8.52$^a$</td>
<td>13.70$^a$</td>
<td>14.56$^a$</td>
</tr>
</tbody>
</table>

**Johansen co-integration results (trace test)**

<table>
<thead>
<tr>
<th>Long-run relationship: $X_{A&amp;ED,t} = \text{Constant} + \beta X_{PC,t} + \mu_t$</th>
<th>0–14 years</th>
<th>&gt; 4 years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A&amp;ED$</td>
<td>$-0.006 + 0.1733$ PC</td>
<td>$0.0072 + 0.0065$ PC</td>
<td>$0.0065 + 0.00014$ PC</td>
</tr>
<tr>
<td>$\text{Trace test}$</td>
<td>24.67$^a$</td>
<td>20.51$^a$</td>
<td>31.43$^a$</td>
</tr>
</tbody>
</table>

A&ED: Hospital Accident and Emergency Department; PC: on-going primary care

a: Means that the null hypothesis of no co-integration is rejected at the 1% level

b: A small sample adjustment, as suggested by Reimers (1992), has been made in the trace test statistics
Certain limitations are inherent in a study of this nature. Among them is that fact that we examined only one healthcare district, with its particular socio-demographic features (aging of the population, low birth rate, and drop in population) and economic circumstances (crisis in the industrial sector, high unemployment, and retirement rates). These factors, together with the specific characteristics of the healthcare system itself (degree of accessibility, resources available, and style of provision of services), may have conditioned the results obtained and limit the scope for extrapolating to other settings. Nevertheless, the area under study showed an increase in the volume of emergency visits that is similar to the trend detected in many other communities, and which over the period analysed minimized the seasonal, and even yearly, variations, which may affect the demand for emergency care. The analysis assumes that the factors that induce people to use emergency services have not changed substanti-
al and suppose that there are no other factors that stimulated the rise in the use of hospital A&ED that would compensate for any possible reduction caused by the improve-
ments in the accessibility of the primary care emergency services. Although observational studies always present this limita-
tion, the steady rise seen in the use of the hospital A&ED (inde-
pendently of rates observed in the use of the primary care emergency services) does not support the hypothesis that other interventions may have had an effect on the trends observed.

The gross growth in emergency visits has happened during a decreasing population period. Hence, the increase in the number of visits per inhabitant is bigger (visits rate/100 inhab-
habitants: hospital A&EDs: 33.9; Primary Care Centres: 59.1). The use of A&EDs is increasing owing to bigger frequentation by previous users and/or the presence of new users. 28 This paper is not focused on the analysis of the A&EDs’ demand increase, but we can point out some determinants like increasing life expectancy, progressive ageing, increasing chronic illness, a low level of social assistance and health education, and the presence of a relevant number of impoverished out-
casts. 4 However, these factors are not enough to explain the emergency visits rising. The generalized idea of A&EDs as an alternative health service, combined with the increase in life expectancy and a higher demand of quality of life, can explain the increase in both hospital and primary care A&ED services.

In light of the meagre success achieved with the interventions applied to decrease inappropriate use of hospital A&EDs, 2–4 options designed to redefine the A&EDs themselves are being examined. For various authors 29–36 these services, as they are conceived today, no longer respond to the needs of the popu-
lation and policies should be devised to redesign them so that they can provide care for both emergency and non-emergency atteners within a reasonable timeframe and at reasonable costs. The results of our study suggest that improvements in emer-
gency care at the primary level increase the use of these services without impacting the use of hospital A&EDs. This raises serious doubts concerning the appropriateness of these strategies to decrease the load of hospital A&EDs in the medium and long terms.

Acknowledgements

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Conflicts of Interest: none declared.

Key points

- Industrialized nations are improving availability of primary care to decrease the use of hospital Accident and Emergency Departments (A&EDs).
- We tested whether the rise in emergency visits to primary care centres decreases hospital A&ED visits.
- A co-integration time-series analysis is applied to a Spanish healthcare district.
- Emergency visits are increasing both in primary care level and hospital A&EDs.
- Increased availability of emergency care at primary level does not seem to substitute A&ED visits.

References

3 New Zealand Health Technology Assessment (NZHTA). Emergency department attendance. NZHTA Reports 8; 1998.
8 Maynard E, Dodge J. Introducing a community health centre at Mosgiel, New Zealand: effects on use of hospital accident and emergency department. Med Care 1983;21:579–89.
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Appendix

To check whether 12 different unit roots are possible in a monthly seasonal process, 12, rather than a single, differing procedures must be used to remove seasonality. That is, an operator \( X_t - X_{t-12} \) termed a seasonal difference, should be applied rather than \( X_t - X_{t-1} \). Note that \( X_t - X_{t-12} = (1 - L^{12}) X_t \) where \( L \) is the lag operator \((LX_t = X_{t-1})\). Then, the polynomial \((1 - L^{12})\) can be expressed as:

\[(1 - L^{12}) = (1 - L)(1 + L)(1 + L^2)(1 + L + L^2)\]

so the 12 unit roots are 1, -1, ±i, -1/2(1 ± i√3), 1/2(1 ± i√3), -1/2(-√3 ± i), and -1/2(-√3 ± i). The first is the unit root at the zero frequency \((1 - L)\), and the remaining are unit roots corresponding to frequencies \(π/3\), ±2π/3, ±π/3, ±5π/6, and ±π/6, respectively.

Hylleberg *et al.* propose a test, and a general framework as a test strategy to examine unit roots at seasonal frequencies, as well as at zero frequency. We applied the monthly version of the HEGY procedure, which has been developed by Beaulieu and Miron (Similar versions have also been developed by Franses and Matea), in order to test the hypothesis of various unit roots, and propose to estimate the auxiliary regression [1] by the Ordinary Least Squares (OLS) method.

\[(1 - L^{12})Y_t = \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + \cdots + \alpha_{12} Y_{t-12} + \varepsilon_t\]

where each \( Y_t \) is a function of the frequency associated with \((1 - L^{12})\). For frequency 0, one simply examines the relevant \(t\)-statistic for \(\alpha_1 = 0\) against the alternative that \(\alpha_1 > 0\). To show that no unit root exists at any seasonal frequency, \(\alpha_k\) must not equal zero for \(k = 2\) and for at least one member of each of the sets \{4, 6\}, \{7, 8\}, \{9, 10\}, and \{11, 12\}. Thus, the latter case needs an \(F\)-type of test statistic, and according to Table A1, we applied filters to remove the unit roots indicated by the tests.

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References


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Table A1 Tests for seasonal unit roots in monthly series, period 1992–1999

Null hypothesis : $S_{12}(1,1)$

<table>
<thead>
<tr>
<th>Test statistics</th>
<th>0–14 years</th>
<th>Over 14 years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A&amp;ED</td>
<td>PC</td>
<td>A&amp;ED</td>
</tr>
<tr>
<td>$t$-statistics</td>
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<td></td>
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<tr>
<td>$\alpha_1$</td>
<td>-0.67</td>
<td>-1.56</td>
<td>-1.28</td>
</tr>
<tr>
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<td>-4.06$^c$</td>
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<td>$\alpha_4$</td>
<td>-2.12</td>
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<td>-2.99</td>
<td>-1.18</td>
</tr>
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<td>-3.46</td>
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<td>$\alpha_9$</td>
<td>-3.77$^b$</td>
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<td>-3.25$^c$</td>
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<td>$\alpha_{10}$</td>
<td>0.71</td>
<td>0.14</td>
<td>-1.08</td>
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<td>$\alpha_{11}$</td>
<td>-1.28</td>
<td>-3.06</td>
<td>2.35</td>
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<tr>
<td>$\alpha_{12}$</td>
<td>2.40$^b$</td>
<td>1.67</td>
<td>2.11$^b$</td>
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<td>$F$-statistics</td>
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<td></td>
</tr>
<tr>
<td>$\alpha_3 = \alpha_4 = 0$</td>
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<td>16.53$^c$</td>
<td>7.08$^b$</td>
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<tr>
<td>$\alpha_5 = \alpha_6 = 0$</td>
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<td>8.96$^c$</td>
<td>6.58$^b$</td>
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<tr>
<td>$\alpha_1 = \alpha_8 = 0$</td>
<td>8.09$^b$</td>
<td>6.01</td>
<td>6.27$^b$</td>
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<tr>
<td>$\alpha_9 = \alpha_{11} = 0$</td>
<td>14.22$^c$</td>
<td>5.18</td>
<td>8.32$^b$</td>
</tr>
<tr>
<td>$\alpha_3 = \alpha_4 = 0$</td>
<td>10.66$^c$</td>
<td>16.53$^c$</td>
<td>17.93$^c$</td>
</tr>
</tbody>
</table>

A&ED: Hospital Accident and Emergency Department; PC: on-going primary care

We have applied the following filters: $(1 - L)(1 - L/3 + L^2)$ for 0–14 A&ED; $(1 - L)(1 - L/3 + L^2)$ for 0–14 PC; $(1 - L)$ for >14 A&ED; $(1 - L)(1 + L/3 + L^2)$ for >14 PC; $(1 - L)(1 - L/3 + L^2)$ for Total A&ED; $(1 - L)(1 + L/3 + L^2)$ for Total PC

a: All series are in log
b: Rejects null hypothesis at 5% significance level.
c: Rejects null hypothesis at 1% significance level