ORIGINAL ARTICLE

Risk of influenza transmission in a hospital emergency department during the week of highest incidence

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Objectives. To estimate the risk of influenza transmission in patients coming to a hospital emergency department during the week of highest incidence and to analyze factors associated with transmission.

Methods. Retrospective observational analysis of a cohort of patients treated in the emergency room during the 2014–2015 flu season. The following variables were collected from records: recorded influenza diagnosis, results of a rapid influenza confirmation test, point of exposure (emergency department, outpatient clinic, or the community), age, sex, flu vaccination or not, number of emergency visits, time spent in the waiting room, and total time in the hospital. We compiled descriptive statistics and performed bivariate and multivariate analyses by means of a Poisson regression to estimate relative risk (RR) and 95% CIs.

Results. The emergency department patients had a RR of contracting influenza 3.29 times that of the community-exposed population (95% CI, 1.53–7.08, *P*=.002); their risk was 2.05 times greater than that of outpatient clinic visitors (95% CI, 1.04–4.02, *P*=.036). Emergency patients under the age of 15 years had a 5.27 greater risk than older patients (95% CI, 1.59–17.51; *P*=.007). The RR of patients visiting more than once was 11.43 times greater (95% CI, 3.58–36.44; *P*<.001). The risk attributable to visiting the emergency department risk was 70.5%, whereas risk attributable to community exposure was 2%.

Conclusions. The risk of contracting influenza is greater for emergency department patients than for the general population or for patients coming to the hospital for outpatient clinic visits. Patients under the age of 15 years incur greater risk.

Keywords: Influenza. Emergency health services. Transmission.

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Riesgo de transmisión de gripe en un servicio de urgencias hospitalario en periodo de máxima incidencia epidémica

Objetivo. Estimar el riesgo de contagio de gripe en la población que acude a un servicio de urgencias hospitalario (SUH) en la semana de máxima incidencia epidémica, así como analizar los factores que influyen en la transmisión.

Método. Estudio analítico observacional de cohortes retrospectivo realizado en sujetos pertenecientes a un Departamento de Salud durante la temporada 2014-15. Las variables estudiadas fueron diagnóstico registrado de gripe, prueba confirmatoria de gripe, grupo de exposición (SUH, consultas externas y población), edad, sexo, vacunación antigripal, número de veces atendido en el SUH, tiempo en la sala de espera y tiempo total en el servicio. Se realizó análisis descriptivo, bivariante y multivariante mediante regresión de Poisson, y se estimaron los riesgos relativos (RR) con sus intervalos de confianza (IC) del 95%.

Resultados. El RR de contraer la gripe en el SUH respecto a la población fue de 3,29 (IC95%: 1,53-7,08; p = 0,002) y con respecto a consultas externas fue de 2,05 (IC95%: 1,04-4,02; p = 0,036). El RR de gripe en el SUH en menores de 15 años respecto a mayores 15 años fue de 5,27 (IC95%: 1,59-17,51; p = 0,007). En sujetos con > 1 visita respecto a 1 visita el RR fue de 11,43 (IC95%: 3,58-36,44; p < 0,001). El riesgo atribuible proporcional fue del 70,5% y el riesgo atribuible poblacional del 2%.

Conclusiones. La población que visita al SUH durante la semana de máxima incidencia epidémica de gripe aumenta significativamente el riesgo de contraerla respecto a la población que no acude a urgencias.

Palabras clave: Gripe. Servicio de Urgencias. Transmisión.

Introduction

The influenza virus uses different routes for its dissemination[1]. It is mainly transmitted by means of drops larger than 5 μm, as well as through fomites and subsequent inoculation into mucosae[2-4]. Although air transmission has been suggested, its possible mechanism has not been demonstrated, although recent studies give it a greater relevance than the one suspected[5-7]. In this sense, aerosolized particles have been detected in environments such as hospital emergency services (HES)6. These characteristics, together with the universal susceptibility, its easy transmission and its presentation in the form of seasonal peaks, give it a high contagious potential in spaces where there is concentration of people. Likewise, there is been an increase in the amount of people infected in the epidemic period, which must be absorbed by the health services[8]. In fact, influenza is one of the main causes of visits to HES, especially among children and people over 65 years of age[8,9], a population in which the most serious cases are recorded.

These units are the first line of care for patients with communicable diseases, due to the acute nature of them, so they can become spaces of high risk of infections related to healthcare[10], facilitated by the multidirectionality of transmission[11-13]. In fact, a high percentage of hospital health personnel meet criteria for influenza contracted in the hospital[14], and HES workers are the most exposed[15], with the consequent risk of community transmission.

In addition, several studies have attempted to model, under theoretical assumptions, the risks of influenza infection in the HES or in other health services, suggesting that they may increase due to the flow of patients, their concentration in the waiting rooms, the proximity between the contacts or the infected staff[16-18].

The main objective of this study was to estimate the risk of contracting the flu in a population exposed to a HES compared to two groups not exposed. Our hypothesis was that the attendance at a HES in the week of maximum incidence of influenza increases the risk of contagion of the same and that a longer time of stay, as well as a greater number of visits, increase the risk among the population served in the HES.

Method

Retrospective cohort study from subjects at risk of influenza infection during the 2014/15 season assigned to a health department, which is equivalent to all subjects of this population, except those who met the exclusion criteria. It was considered "exposed", from the previous population, to the subjects without diagnosis of influenza who attended the HES during the week of maximum incidence and as "not exposed" to those without diagnosis of influenza and who did not state that they had attended to HES, selected among patients visited in hospital outpatient departments (OPDs) and among the population (POP). The patient with the flu diagnosis registered in the clinical history between 1 and 8 days later was considered as "case" to attendance, regardless of whether a confirmatory test was performed, so that both the exclusively clinical diagnosis and that confirmed by rapid influenza diagnostic test (RIDT) or PCR were included as cases. Regarding the population group, since there was no reference day, it was considered a case registered between 1 and 8 days after the last reference for the previous groups. For the calculation of the size of the sample, assuming a proportion of influenza in exposed of 1% and a proportion of 0.4% in unexposed, a type I error of 5%, a power of 80% and a relationship not exposed / exposed of 2, it was estimated that a sample of 2,134 subjects was necessary for the exposed group and of 4,268 for the unexposed, to detect a RR of 2.5, with the sample size for the study group similar to that of our group exposed to HES With respect to the comparison groups we had samples superior to the necessary ones, corresponding to OPD all the population attended in that period. The selection of the subjects of the population sample was made by simple randomization. Our variable outcome was influenza and as independent variables were considered the exposure group (HES, OPD and POP), age, sex, vaccination, number of visits and waiting times and stay in the HES.

Regarding the statistical analysis, first, the baseline characteristics of the cohort were described, with absolute and relative frequencies for the qualitative variables and with mean and standard deviation (SD) for the quantitative ones. Second, a bivariate analysis was carried out to compare differences in the variables studied between the comparison groups. For the qualitative variables, the chi-squared test or Fisher's exact test was used in cases in which the conditions of applicability were not met. For the quantitative variables the Student t test was used. Finally, a multivariate analysis was performed using Poisson regression, using the deviation parameters, maximum likelihood ratio and robust estimators to adjust our model. As a measure of association, the relative risk (RR) was calculated, with its 95% confidence intervals (CI) and as proportional and population-based attributable impact measures. The level of statistical significance was established at 0.05. The analyses were performed through the SPSS program in its version 22 (IBM, North Castle, NY, USA).

The study was carried out following the principles of the Declaration of Helsinki. By not including any intervention, there has been no risk to patients. The confidentiality of the information has been maintained according to the Organic Law of December 13 on the protection of personal data and approval was obtained from the Clinical Research and Ethics Committee (CEIC) of the Dr. Peset Hospital in Valencia.

Results

The flow diagram with the excluded subjects and the reasons can be seen in Figure 1. The description of the baseline characteristics of the sample is shown in Table 1. Waiting times were only recorded in the HES group. The total cases of influenza registered in the HES were 68, with 5 subjects that met the case criteria in the population group, 8 in the OPD and 8 in the HES, representing 0.1%, 0.1% and 0.3% of the total number of subjects at risk. 0.8% of the population under 15 years of age fulfilled criteria for infection in the HES. None of the population cases was confirmed, which was done by 50% in OPD and 75% in HES.

The results of the bivariate analysis are shown in Ta-

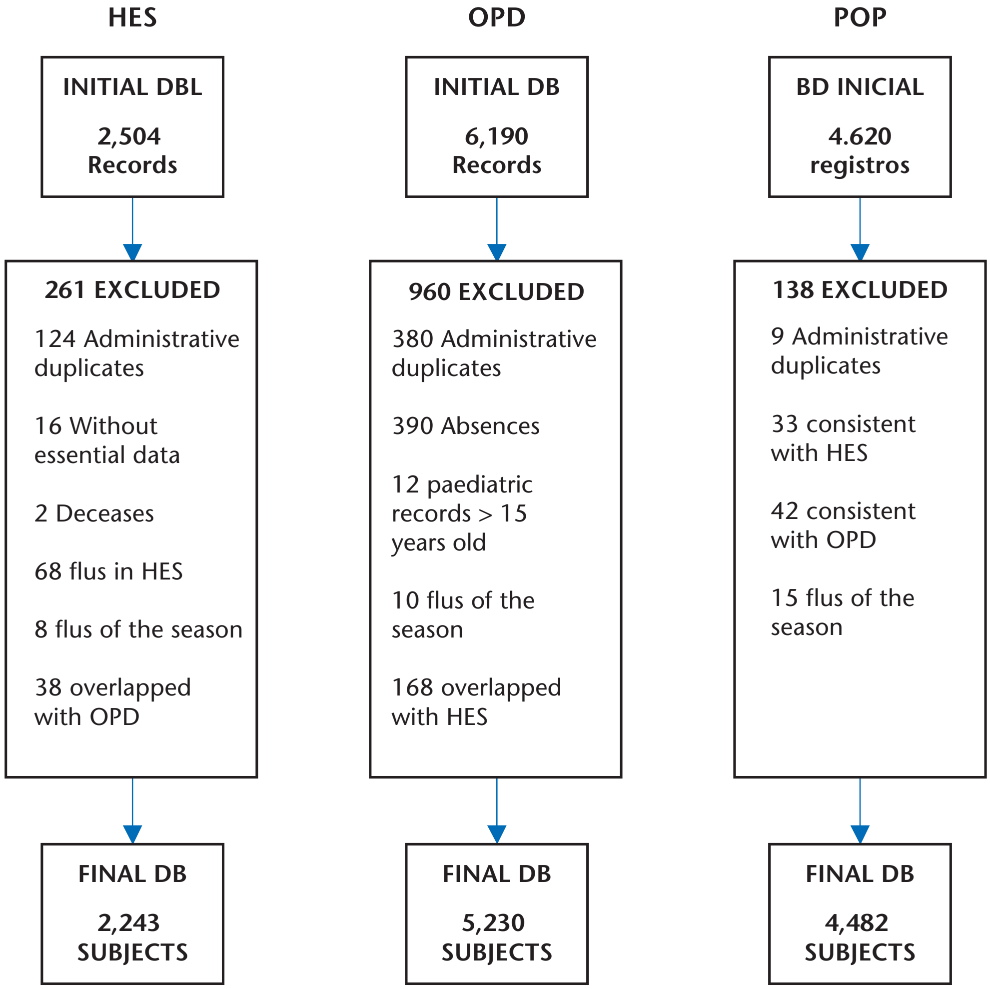

Figure 1. Flow chart. DB: database; HES: Hospital emergency services; OPD: Outpatients department; POP: population group.

ble 2. When comparing the HES groups and the population, we observed that the first group had a RR of 3.2 with respect to the population (95% CI: 1.047-9.808, p = 0.041).When analysing the OPD and HES groups, subjects under 15 years of age had an RR of influenza of 3.4 (95% CI: 1,179-9,813, p = 0.024), and those with a number of visits to the HES higher than 1 of 4.5 (95% CI: 1.283-15.942, p = 0.019); The HUS group presented a RR of 2.3 with respect to CEH, although it did not obtain significant differences (p = 0.090). When performing the intra-group analysis of HED, we observed that those under 15 years of age and the number of visits greater than 1 had a RR of 4.9 (95% CI: 1,223-19,730, p = 0.025) and 12.3 (95% CI: 2,899-52,141, p = 0,001) respectively. On the other hand, neither the waiting nor the stay time showed significance.

Finally, when performing the Poisson regression of the entire cohort (Table 3), adjusted by age group and vaccination, we observed that the HES group showed a RR of 3.3 of suffering from the flu with respect to the population (95% CI: 1,534-7,083, p = 0,002) and that the OPD group presented a RR of 1.5 with respect to the population, not showing the latter significance.

With regard to the HES and OPD groups (Table 4), we observed that in the HES, the age under 15 years and the number of visits greater than 1 increased the risk of infection with an RR 2 (95% CI: 1,047-4,020; p = 0.036), of 3.1 (95% CI: 1.536-6.402, p = 0.002) and 4.5 times (95% CI: 1.316-15.456, p = 0.017), respectively. Regarding the intra-group analysis of HUS (Table 5), we observed that the number of visits greater than 1 and the age under 15 years had a RR of 11.4 (95% CI: 3,588-36,449 p < 0.001) and of 5, 3 (95% CI: 1,590-17,510; p = 0.007), respectively. Although the waiting time greater than 90 minutes shows a RR of 1.6, this is not statistically significant.

When analysing the HES group, the proportional attributable risk was 70.5% and among the population assigned to the hospital, the population attributable risk was 2%.

Discussion

According to the results of our study, being treated in the HES increases more than 3 times the risk of

Table 1. Patients included in each study group

	Study group			p
	HES N = 2,243 n (%)	OPD N = 5,230 n (%)	POP N = 4,482 n (%)	
Sex				0.342
Female	1,263 (56.3)	2,850 (54.5)	2,457 (54.8)	
Male	980 (43.7)	2,380 (45.5)	2,025 (45.2)	
Vaccination				< 0.001
Yes	479 (21.4)	1,591 (30.4)	575 (12.8)	
No	1,764 (78.6)	3,639 (69.6)	3,907 (87.2)	
Age (SD) in years	46 (27)	54 (23)	40 (24)	< 0.001
Group of age				< 0.001
≥ 15 years old	1,861 (83)	4,728 (90.4)	3,517 (78.5)	
< 15 years old	382 (17)	502 (9.6)	965 (21.5)	
N of visits				0.408
1 Once	2,136 (95.2)	4,972 (95.1)		
> Than once	107 (4.8)	258 (4.9)		
Waiting time in the emergency department (SD) in min.	60 (51)			
Time of stay in the emergency department (SD) in min.	195 (162)			
Flu				0.067
Yes	8 (0.35)	8 (0.15)	5 (0.11)	
No	2,235 (99.65)	5,222 (99.85)	4,477 (99.89)	
Confirmation of the flu				0.002
Yes	6 (75)	4 (50)	0 (0)	
No	2 (25)	4 (50)	5 (100)	

SD: Standard deviation; N: Number; HES: Hospital emergency services; OPD: Outpatients department; POP: Population; min: minutes.

contracting the flu with respect to the general population and twice as much as in the OPD group, regardless of age and previous influenza vaccination. Given the variable number of visits shared in both groups, we observed that those patients who visited more than once said services increased their risk by 4.5 times, which is explained by the dose-response relationship, so that it could be expected an increased risk of influenza at increased exposure. Also, the age under 15 years increased the risk 3 times in a significant way.

Table 2. Result of the bivariate analysis between the different groups

	RR	ICI 95%	p
Group			
POB	1	(reference)	
HES	3.205	1.047-9.808	0.041
OPD	1.372	0.448-4.196	0.580
Male	0.915	0.385-2.173	0.840
No vaccination	0.909	0.333-2.484	0.852
Age < 15 years old	2.19	0.849-5.652	0.105
Group			
OPD	1	(referencia)	
HES	2.336	0.876-6.233	0.09
Male	1.225	0.459-3.266	0.686
No vaccination	1.150	0.370-3.569	0.809
Age < 15 years old	3.402	1.179-9.813	0.024
N of visits > 1	4.523	1.283-15.942	0.019
Group HES			
Male	1.290	0.322-5.171	0.719
No vaccination	0.814	0.164-4.046	0.801
Age < 15 years old	4.913	1.223-19.730	0.025
N of visits > 1	12.294	2.899-52.141	0.001
Waiting time ≥ 90 minutes	1.206	0.243-5.995	0.819
Waiting time ≥ 240 minutes	0.779	0.157-3.868	0.760

RR: relative risk; CI: confidence interval; HES: Hospital emergency services; OPD: Outpatients department; POP: population group.

Table 3. Poisson regression model for the entire cohort

	RR	CI 95% Low	CI 95% High	p
HES groups	3.297	1.534	7.083	0.002
OPD groups	1.504	0.896	2.525	0.122
POP groups	1	(reference)		
Age < 15 years old	2.364	1.174	4.760	0.016
No vaccination	0.802	0.493	1.304	0.374

RR: relative risk; CI: confidence interval; HES: Hospital emergency services; OPD: Outpatients department; POP: population group.

Regarding the exclusive analysis of the HES group, we found similarly that patients under the age of 15 and also the number of visits higher than 1 increased the risk of infection by 5.3 and 11.4 times, respectively, and significant way to be adjusted by the other variables. Contrary to what was expected, there was no association between the fact of being vaccinated or between the time in waiting or stay in the HES with respect to contagion.

With reference to children, its importance as a focus of origin and spread of flu in the community is known[19-21]; Outbreaks can start in schools and spread among cohabitants. The number of visits of children to the HES may be an anticipatory index of the subsequent increase in cases in adults and the secondary attack rate may reach 30% among children under 4 years of age. These characteristics may partly explain the increase in cases among the children in our study, as well as the fact that in the 2014-15 season this population was also the most affected[20-23]. However, this risk should have been distributed evenly among our groups, but it is in the OPD and HES groups where this variable has increased the risk significantly. We believe that the concentration of children in both waiting rooms for long periods of time and in proximity to other sick children, mainly in our HES, whose children's waiting room has a small surface area (20 m²), could have contributed to the contagion.

Regarding the proportional attributable risk, among those attending the HES, 70.5% of cases of flu could theoretically be avoided if said exposure were eliminated. Similarly, among the population assigned to our hospital, 2% of the cases of flu could theoretically be

Table 4. Poisson regression model for the HES / OPD groups

	RR	CI 95% Low	CI 95% High	p
OPD groups	1	(reference)		
HES groups	2.051	1.047	4.020	0.036
Age < 15 years old	3.136	1.536	6.402	0.002
N of visits > 1	4.510	1.316	15.456	0.017
No vaccination	0.858	0.408	1.803	0.686

RR: relative risk; CI: confidence interval; HES: Hospital emergency services; OPD: Outpatients department.

Table 5. Poisson regression model for the emergency group

	RR	CI 95% Low	CI 95% High	p
Number of visits > 1	11.436	3.588	36.449	0.000
Age < 15 years old	5.277	1.590	17.510	0.007
Waiting time ≥ 90 minutes	1.624	0.427	6.178	0.477
Waiting time ≥ 240 minutes	0.556	0.170	1.817	0.331
No vaccination	0.410	0.100	1.681	0.216

RR: relative risk; CI: confidence interval; min: minutes.

avoided if they did not attend the HES during the week of greatest incidence.

There are few studies conducted on the risk of influenza transmission in HES. According to the study by Quach et al.[24], the risk of respiratory disease in children treated in an HES was not greater than that of the community. Maltezou et al.[25] found that 3.6% of children developed a respiratory infection after the visit to the HES and 0.49% were compatible with influenza. Neither of the two studies assessed the risk of infection in adults. The first of them had little sample and the second group had control, which may be limitations that our study lacks. Although we agreed on the low risk of infection, the incidence of influenza in our children was higher, standing at 0.8%. Differences in criteria may have influenced these variations.

Regarding studies in adults, in a prospective study[26] it was concluded that at least 14 of the 43 cases of influenza diagnosed in the hospital could have been associated with the visit to the HES. In another study[16], the effects of ventilation degrees on the possibility of contagion of influenza were evaluated, based on the growing evidence of the possibility of aerial transmission. A pulmonary function laboratory, a room for OPD and another for isolation with negative pressure of the HES were selected and the rates of air exchange were measured, estimating the risk of infection in the persons who occupied it after remaining an infected subject. In those whose stay exceeded 30 minutes in the isolation room, a risk of 0.3% was calculated, a very low risk and similar to our incidence (0.35%). On the other hand, they found a greater risk in the OPD room, which reached 3.6% at 15 minutes, 8.1% at 60 minutes and up to 18.5% at 120 minutes. In our study, we did not find a significant relationship between the length of stay in the HES and the risk of infection, which may have been more influenced by the patient's close and random contact with an infected subject than the time spent in the service. On the other hand, Beggs et al.[27] studied the potential risk of airborne influenza transmission in waiting rooms, varying their occupation, degree of ventilation, concentration of pathogens and waiting times. After a wait of 30 minutes, the risk of contagion of influenza was 0.0262, increasing to 60 minutes to 0.0622. The authors recommend minimizing waiting times and the susceptible population. We share these solutions and, although we have not found a relationship with waiting times, we have done so with the number of visits, which indicates an incremental dose-response relationship. Finally, a modelling based on the agent of the spread of influenza in a HES[18] created a framework with 20 possible scenario simulations. An increased risk was found in relation to close contact, the entry of patients or infected physicians or the small size of the waiting room. Rejecting patients of low priority or discharging them quickly would reduce the percentage of infected persons by 7 times. In a similar way, putting the mask on the same patients would reduce it 3 times, and put it on infected toilets twice, while giving them off twice did it twice.

As limitations of the study, we must emphasize that we consider as influenza the diagnosis coded as such and that had been registered in the study period. Working on records may have caused us to lose a case whose onset of symptoms, despite a subsequent recorded diagnosis, started during the criterion period and, on the contrary, some case considered as such by the registry could have been initiated earlier. It has been possible to produce possible classification biases by not considering the possible visits of the subjects to other health centers before the visit to the HES. Also when considering the subjects of those who did not register after the visit as not infected, being able to be self-treated subjects. In both cases, it would be a non-differential classification bias equally distributed among the groups and that, in any case, would tend to underestimate the association found. Also, the failure to correspond to the diagnosis of influenza coded with real flu. In this case, it is possible that there is a differential classification bias, since it is more probable that in the HES confirmatory test has been carried out than in the other groups, where it is not usual practice, and there may have been an underestimation of the effect. This attempt has been made to reduce the diagnosis according to the incubation period and the contact period, and also taking into account that the study has been carried out in the period of greatest incidence, when the symptoms have a higher predictive value, according to the studies carried out in this regard[4,28], as well as collecting laboratory data. So, if both biases tend to underestimate the risk, this could be higher than the one described.

As strengths, the size of the sample could be highlighted, with which we have minimized the type II error, the availability of two comparison groups, the primacy of the specificity, limiting ourselves to diagnoses declared as such in the surveillance system, and the fact that have been designed as a cohort study on records that allowed us to calculate the RR. In short, we note that the results are in line with other studies, in the sense of focusing attention on the HES, where the ideal conditions for the transmission of influenza. We also agree on the estimation of the low probability of contracting it in this device. However, this risk is 2 times higher than that of being infected in OPD and more than 3 times that of being in the population, the magnitude of the impact being significant, measured by the attributable risks, especially the proportional one, since the relevance at a population level it is discrete. We also found a special risk among children who come to the HES, which could be related, among other baseline causes, to the small size of our waiting room.

Regarding measures that can be implemented to reduce the risk of infection, we could consider the educational advice to the population, improving out-of-hospital referral circuits, create specific itineraries for patients suspected of having influenza in the ED, encourage the use of the mask among symptomatic patients and between health services, and prevent them from working in HES when they show symptoms[18]. In the same way, we should insist on seasonal influenza vaccination and consider introducing the infant population as potentially vaccineable, given that it is the population where the outbreaks begin and the one that most easily transmits the infection. Although in one study their vaccination is considered in the HES[29], we think that it is not the ideal means of vaccination, for logistical reasons, coincidence of the vaccination with the ill patient and overload of care.

We believe that this work sheds light on this field, and it is necessary to improve the research and extend it to other geographic locations, to determine the possible variability between different services and to specify the determinants that increase the risk of contagion in these spaces. As a final conclusion of our work, it should be noted that the visit to the HES in the week of maximum epidemic incidence increases the risk of contracting the flu with respect to the general population that does not visit an HES and the people who attend the outpatient consultations. Just as being under 15 years of age and having more than one emergency visit increases the risk of other HES patients.

Conflicting interests

The authors declare no conflict of interest in relation to this article.

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Ethical Responsibilities

The study was approved by the Ethics and Clinical Research Committee of the Dr. Peset Hospital in Valencia.

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