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ORIGINAL PAPER

The impact of home hospitalization on healthcare costs of exacerbations in COPD patients

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Abstract Home-hospitalization (HH) improves clinical outcomes in selected patients with chronic obstructive pulmonary disease (COPD) admitted at the emergency room due to an exacerbation, but its effects on healthcare costs are poorly known. The current analysis examines the impact of HH on direct healthcare costs, compared to conventional hospitalizations (CH). A randomized controlled trial was performed in two tertiary hospitals in Barcelona (Spain). A total of 180 exacerbated COPD patients (HH 103 and CH 77) admitted at the emergency room were studied. In the HH group, a specialized respiratory nurse delivered integrated care at home. The average direct cost per patient was significantly lower for HH than for CH, with a difference of 810€ (95% CI, 418–1,169€) in the mean cost per patient. The magnitude of monetary savings attributed to HH increased with the severity of the patients considered eligible for the intervention.

Keywords COPD · Healthcare costs · Healthcare delivery · Homecare · Hospitalization

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Introduction

Hospital admissions related to acute exacerbations of chronic obstructive pulmonary disease (COPD) have a deleterious impact on health related quality of life and on mortality risk in these patients. Moreover, the burden of exacerbations for the entire health system is high [1], both from an economic and organizational point of view [2, 3]

The overall economic burden of COPD (direct and indirect costs) has been estimated as being equivalent to 0.32% of US gross domestic product in 2001, and direct medical costs attributed to COPD accounted for 1.5% of US healthcare expenditure [4]. Empirical evidence in many countries showed that expenditures for COPD patients are more than 2.4 times that of all healthy insured population [2]. Moreover, expenditure for hospitalizations represent >70% of all COPD-related medical care costs [5].

There has been controversy regarding the effects of home hospitalization (HH) schemes on costs. Two

randomized controlled trials [6, 7] reported that HH significantly increased healthcare costs for COPD patients [8]. However, four controlled trials conducted in the United Kingdom [9–11] and in Barcelona (Spain) [12] have shown both safety and cost reductions when these type of services, either HH directly from the emergency rooms or early discharge from the hospital, are applied to appropriately selected COPD patients with a well-defined intervention at home.

Using the same data set reported by Hernandez et al. [12], the current analysis assessed whether HH is associated with lower direct health care costs than conventional hospitalization (CH). The main objectives of the current study were: (1) to determine the marginal impact of HH, in comparison with CH, on direct patient health care costs; and (2) to predict health costs of exacerbated COPD patients conditional on individual disease severity and treatment characteristics, including the intervention (HH).

Methods

Study design

Over a 1-year period (1 November 1999 to 1 November 2000), 222 patients with COPD exacerbations were included in the study among those admitted at the emergency room (ER) of two tertiary hospitals (Hospital Clínic and Hospital Universitari de Bellvitge) of Barcelona, Spain. The two primary criteria for inclusion in the study were: (1) COPD exacerbation as major cause of referral to the ER; and (2) absence of any criteria for imperative hospitalization as stated by the British Thoracic Society (BTS) guidelines [4] (i.e., acute chest X-ray changes; acute confusion; impaired level of consciousness; and arterial pH below 7.35). Patients that agreed to participate were randomly allocated to either the intervention group (HH) or the control group (CH). A detailed description of the study groups (HH and CH), characteristics of the intervention, and generalities of the cost analysis are reported in Hernández et al. [12].

One hundred and sixty-five (26.2%) of the 629 screened patients required imperative hospitalization. Two hundred and twenty patients showing at least one exclusion criteria (not living in the health care area or admitted from a nursing home; lung cancer and other advanced neoplasms; extremely poor social conditions; severe neurological or cardiac comorbidities; illiteracy; no phone at home) were not considered in the program. Up to 244 patients (38.8%) were considered eligible for the study, but 22 subjects (3.5%) did not sign the informed consent after full explanation of the characteristics of the protocol. The remaining 222 patients (35.3%) were blindly assigned using a set of computer-generated random numbers in a 1:1 ratio either to the treatment group (home-based hospitalization (HH)) or to the control group (conventional care) [12]. One of the hospitals used a 2:1 randomization ratio during the first 3 months of the study, which explains the difference in number between the two groups.

Intervention group

A specialized team assessed only patients assigned to HH. For each HH patient, the nurse scheduled a first home visit within 24 h after discharge. The respiratory nurse set the length of the HH. A maximum of five nurse visits at home were permitted during the 8-week follow-up period, but patient's phone calls to the nurse were not limited in number. The intervention was considered to be a failure if one of the two following events occurred: the patient relapsed and required referral to the ER, or >5 nurse visits at home were needed during the follow-up period. In both circumstances, the patients were analyzed in the study, but they were not considered for a new randomization (i.e., when attended at the ER for the relapse).

The HH intervention had three main objectives: (1) an immediate or early discharge from the hospital was encouraged by the specialized team aiming to either avoid or reduce the length of inpatient hospitalization; (2) a comprehensive therapeutic approach was tailored on an individual basis, according to the needs detected by the specialized team; and (3) patient support by a skilled respiratory nurse either through home-visits or free-phone consultation was ensured during the 8-week follow-up period.

Control group

Patients included in the conventional care group (controls) were evaluated by the attending physician at the ER who decided either on in-patient hospital admission or discharge. Pharmacological prescriptions followed the standard protocols of the centers involved in the study that were similar in the two groups, but the support of a specialized nurse at the ER and at home was not provided to controls. At discharge, the patient was usually supervised by the primary care physician who was not aware of the protocol.

In the present study, sample size was reduced to 180 patients (HH 103 and CH 77). The remaining 42 patients were excluded from the cost analysis and

subsequent multivariate linear regression models: 12 patients died during the follow-up, 16 patients had missing data in the dependent variable (total cost), and 14 patients had missing data in some potential explanatory variables (socio-demographic, clinical or functional data).

Measurement and valuation of resources

Costs were calculated for each group from the perspective of the public insurer, such that, the cost analysis was restricted to direct healthcare costs; patient time and informal care were not evaluated in this study.

The categories to be considered to estimate the cost at individual patient level were: (1) hospital length of stay (days of initial hospitalization plus days during hospital re-admissions); (2) emergency room visits not requiring admission to the hospital; (3) hospital outpatient visits to specialists; (4) primary care physician visits; (5) visits for social support; (6) nurse visits at home; (7) ambulatory treatment prescriptions; (8) phone calls; and (9) transportation services. Data on use of categories were obtained for each patient during the follow-up period.

Independently of the type of resource, individual costs for each patient have been calculated according to the initial assignment to the HH or the CH group. Real savings in the number of each type of resource (hospitalization, visits, drugs, etc.) have been reported in a previous paper [12].

The total cost for each category was calculated as the product of the number of events times the unit cost per event (i.e., hospitalization costs were calculated as days in hospital including initial stay plus readmissions times the average hospitalization cost per day). Unit costs are expressed as year 2000 prices using euros (€). Costs for nurse visits at home, ambulatory drug prescriptions, phone calls and transportation services were directly calculated using information about labor cost, market prices including value added tax, and overhead costs. Hospital unit costs per in-hospital stay and visits were calculated as average observed tariffs for COPD patients in a public insurance company covering the civil servants of the City Council of Barcelona (PAMEM). These tariffs are mainly paid to public and non-profit hospitals and they represent an adequate basis for estimation of costs in the current study given that our interest is in the financial costs for third party insurers. Calculation of costs for individual COPD patients included in the randomized controlled trial followed quality recommendations for costing in the health economics literature [13].

Statistical analysis

We computed the difference in the mean cost per patient between treatment groups. Because cost data were non-normally distributed, a 95% confidence interval (95% CI) was estimated by the re-sampling technique of bootstrapping. We estimated confidence intervals for the mean of all the cost variables included in the model using the bias-corrected and accelerated (BCa) confidence interval with 1,000 bootstrap replicates of the same original sample size [13]

We estimated a multivariate cost function to evaluate the average marginal contribution of the HH on healthcare costs using total cost as the dependent variable, and some explanatory variables plus the intervention (HH or CH) as independent variables. Potential explanatory variables to be included in the multivariate cost function were selected from the results of the comparisons carried out between the two groups (HH and CH) plus those variables included according to the observation of their potential predictive value of COPD costs in the literature. The latter was completed surveying the results of an extensive bibliographic search (Medline and Cochrane Library) for the terms ''COPD exacerbations'', ''health care costs'', and ''economic evaluation''.

Several empirical specifications for the cost function were considered: (1) without log transformation of cost, (2) with log transformation of cost, and (3) with log transformation of cost with bias correction. We decided to use the log transformation of the dependent variable, because the total cost (dependent variable) is badly skewed to the right, and a scale transformation is needed to normalize data and obtain more precise and robust estimates. However, the scale of ultimate interest is the original scale, thus back-transformation was done. The re-transformation yields a biased estimate of the arithmetic mean of the distribution of predicted cost per patient [13]. To correct for this bias, we used the smearing estimator [13]. The study of correlation and the multicollinearity between variables, and normality and heteroscedasticity tests were performed.

Predictive validity is examined within the entire test sample. As the mean expected cost per patient is the statistical of interest, the validation criteria based on the root mean square error (RMSE) are proper for choosing between the three competing models [14]. Using the best model, the one with the minimum RMSE score, the expected cost for a given patient type was calculated.

Results

Factors determining mean cost per patient

The mean overall patient costs were 1,154€ for HH and 1,964€ for CH. Table 1 indicates the 2.5 and 97.5 percentiles for the mean patient cost of HH (95% CI, 923–1,452€) and CH (95% CI, 1,573–2,621€). A difference in favour of HH amounting to 810€ (95% CI, 418–1,169€) in the mean cost per patient was observed.

The main factors contributing to this cost difference were in-patient hospital stays (846 vs 1,713€, HH and CH, respectively), pharmaceutical ambulatory prescriptions (220 vs 176€), nurse home visits (40 vs 0€), phone calls (20 vs 0€), and emergency room visits (10 vs 28€). No statistically significant differences between groups were observed in the average cost of outpatient visits, primary care physician visits, social support visits, and transport.

It is of note, that in-patient hospital stays were the main input contributing to mean cost per patient in the two groups (HH and CH) of exacerbated COPD patients. The proportion of hospital stays cost on overall patient cost was 87% in CH, and it only decreased to 73% in HH. Thus, HH was cheaper than CH by 867€ (95% CI, 719–1,184€) for the mean in-patient hospital stay cost per patient observed in our study.

Pharmaceutical ambulatory cost represented 9% of mean CH patient cost and 19% of mean HH patient cost. Mean pharmaceutical ambulatory cost per patient was significantly higher in HH than in CH, with a difference of 44€ (95% CI, 40–49€) per patient. However, given that this study is not able to distinguish the utilization of drugs inside the hospital, differences in drug expenditure only refer to ambulatory drug consumption, and overall differences in drug consumption cannot be well established. Main characteristics of HH and CH are compared in Table 2. This analysis was done to identify potential explanatory variables to be included in the multivariate cost function model.

Multivariate cost function

The comparison of the three competing multivariate regression models alluded to in Methods showed the lowest RMSE (1,564€) for the log-transformed linear model with bias correction (*smearing estimator*) which was adopted in the current study. Alternatively, the RMSE values for the linear model and for the model with log-transformation model without bias correction were 1,590 and 1,690€, respectively. Table 3 indicates the covariates included in the multiple regression analysis and the corresponding estimated coefficients. Four variables predicted the total cost: (1) FEV_1, expressed as percent of predicted value; (2) health related quality of life, expressed as the total score of Saint George's Respiratory questionnaire (SGRQ); (3) the number of COPD exacerbations requiring in-hospital admission in the previous year; and (4) the intervention (HH). As shown in the table, high SGRQ total score (poor health related quality of life), high number of in-hospital admissions during the previous year and low FEV_1 were independently associated with higher costs. In contrast, HH was related to lower costs independently of any effect associated with other potential explanatory factor.

Table 1 Mean average health care cost per patient, according to treatment group

Categories	Home hospitalization (n = 103)					Conventional hospitalization (n = 77)				
	% of zeros	Skewness	Mean	BCa's percentiles		% of zeros	Skewness	Mean	BCa's percentiles	
				2.5%	97.5%				2.5%	97.5%
In-patient hospital stay	34.00	2.809	846.07	627.59	1,130.13	11.70	2.942	1,713.38	1,346.31	2,313.72
Emergency room visits	90.30	3.449	10.06	4.64	16.25	75.30	1.678	27.95	18.63	40.37
Outpatient visits	90.3	3.458	4.64	2.32	7.74	85.70	8.252	24.84	7.25	94.32
Primary care physician visits	96.1	7.139	4.61	0.92	12.89	89.60	4.072	9.25	3.70	17.36
Social support visits	98.1	8.105	0.55	0.00	2.06	94.80	5.657	2.68	0.73	7.63
Nurse home visits	14.6	0.343	40.11	35.19	45.52	–	–	–	–	–
Ambulatory prescriptions	0.0	0.123	219.96	204.59	235.88	0.00	0.016	175.54	155.28	195.66
Total phone calls	16.5	1.291	20.22	17.16	23.80	–	–	–	–	–
Transport	33.0	1.054	8.11	6.83	9.82	27.30	1.283	10.62	8.59	13.13
Average direct cost per patient	0.0	2.838	1,154	923	1,452	0.00	2.812	1,964	1,573	2,621

Costs are expressed in euros at year 2000 prices

% of zeros refers to the proportion of patients without hospitalization

Table 2 Comparison of sociodemographic and health characteristics of the intervention and control groups

	Home hospitalization (n = 103)	Conventional hospitalization (n = 77)	Total patients (n = 180)
Sex[a]**			
Female	2 (1.9)	2 (2.6)	4 (2.2)
Male	101 (98.1)	75 (97.4)	176 (97.8)
Age (years)[b]**	70.8	70.7	70.8
Marital status[a]**			
Married or living in pair	79 (76.7)	51 (66.2)	130 (72.2)
Unmarried, divorced, separated or widowed	24 (23.3)	26 (33.8)	50 (27.8)
Labor situation[a]**			
Working	15 (14.6)	8 (10.4)	23 (12.8)
Not working	88 (85.4)	69 (89.6)	157 (87.2)
Studies[a]**			
Primary	90 (87.4)	68 (88.3)	158 (87.8)
Secondary or university	13 (12.6)	9 (11.7)	22 (12.2)
Annual income[a]**			
≤12,000€	86 (83.5)	65 (84.4)	151 (83.9)
>12,000€	17 (16.5)	12 (15.6	29 (16.1)
PaO_2 (mmHg)[b]**	66.06	65.23	65.71
$PaCO_2$ (mmHg)[b]**	42.26	43.94	42.98
FEV_1 (% predicted)[b]**	43.0	39.2	41.4
FEV_1/FVC (%)[b]**	50.0	50.7	50.3
Dyspnoea score (VAS)[b]**	6.3	6.3	6.3
Co-morbidity[a]**			
Yes	96 (93.2)	75 (97.4)	171 (95.0)
No	7 (6.8)	2 (2.6)	9 (5.0)
No. of chronic upsets[b]**	2.88	3.13	2.99
Exacerbations requiring in-hospital admission in the previous year[b]**	0.56	0.91	0.71
Exacerbations requiring emergency room admission in the previous year[b]**	0.55	0.89	0.70
Total SGRQ score[b]**	51.8	46.4	49.5
Physical summary SF-12 score[b]*	37.0	34.3	35.9
Mental summary SF-12 score[b]**	44.3	43.2	43.9
Vaccination in previous year[a]**			
Yes	68 (66.0)	49 (63.6)	117 (65.0)
No	35 (34.0)	28 (36.4)	63 (35.0)
Current smoker[a]**			
Yes	27 (26.2)	13 (16.9)	40 (22.2)
No	76 (73.8)	64 (83.1)	140 (77.8)
Respiratory rehabilitation exercises in the previous 4 weeks[a]**			
Yes	10 (9.7)	7 (9.1)	17 (9.4)
No	93 (90.3)	70 (90.9)	163 (90.6)
Compliance on oral medication[a]*			
Yes	42 (40.8)	42 (54.5)	84 (46.7)
No	61 (59.2)	35 (45.4)	96 (53.3)
Compliance on inhalation therapy[a]**			
Yes	63 (61.2)	50 (65.0)	113 (62.8)
No	40 (38.8)	27 (35.0)	67 (37.2)
Clinical outcomes (8-week follow-up)			
Inpatient hospital readmissions (number of episodes)[b]*	0.24 (0.57)	0.38 (0.70)	0.30 (0.62)
Emergency room readmissions (number of episodes)[b]*	0.13 (0.43)	0.31 (0.62)	0.21 (0.51)

Results are expressed either as mean or number of subjects in the corresponding category. Percentage of subjects is expressed within brackets. Annual income, expressed in euros at year 2000 prices

PaO_2 partial pressure of oxygen, *$PaCO_2$* partial pressure of carbon dioxide, *FEV_1* forced expiratory volume during the first second, *FEV_1/FVC* ratio, *VAS* visual analogical scale for scoring dyspnoea, *SGRQ* Saint-George's respiratory questionnaire, *SF*-12 questionnaire

*$P > 0.05$; **$P > 0.1$

[a] Chi-square test

[b] *U* Mann–Whitney non-parametric test for independent samples

Home hospitalization savings and disease severity

We estimated the costs per individual patient for four different degrees of disease severity, as indicated in Table 4 and Fig. 1. Given the regression model chosen in the current study, a back transformation and smearing was needed to estimate the expected cost per patient [15]. The so-called ''average'' patient was

Table 3 Multivariate estimate of patient costs

Dependent variable log (cost)		
Explanatory variables	Estimated coefficient (OLS)	Standard error
Constant	6.979586	0.294397**
FEV1	–0.009642	0.004817*
Total SGRQ score	0.006030	0.002978*
Exacerbations requiring in-hospital admission in the previous year	0.169333	0.072935*
Intervention group (HH = 1)	–0.406642	0.160144*
Smearing factor	1.5811	
R^2	0.138	
Adjusted R^2	0.118	

FEV1 forced expiratory volume during the first second at 8 weeks of follow-up, *Total SGRQ score* total Saint George Respiratory Questionnaire score, *HH* home hospitalization

*$P < 0.01$; **$P < 0.05$

defined by values of each covariate equal to the sample mean values. The estimated cost for the ''average'' COPD patient was 1,154€ with HH and 1,801€ with CH. In other words, estimated savings attributable to the intervention (HH) in this hypothetical patient were 647€.

It is noteworthy that differences in cost due to HH increased when disease severity augmented. Cost savings were 458€ for a light COPD patient, 775€ for a moderate COPD patient, and 1,419€ for the highest disease severity considered in the analysis.

Discussion

A cost minimization analysis

In the current study, we demonstrated that HH decreased direct patient health cost by –36% cost in comparison to CH. The results obtained from the multivariate cost function clearly provide a useful insight on the efficiency gains than can be expected from integrated home care programs in the management of COPD exacerbations. The multivariate cost function has proven to be useful for disease cost forecasting and for evaluation and budgeting purposes.

In a previous paper using data from the same randomized controlled trial [12], a noticeable improvement in quality of life ($P = 0.03$) and in other clinical outcomes was demonstrated. But differences between HH and CH in most clinical outcomes disappeared when a more stringent threshold ($P = 0.01$) was adopted. In the current study, we assumed no differences in clinical outcomes between HH and CH [16]. Then, we might consider that the two alternative programs may be viewed as equivalent in outcome and adopt the simple approach of a cost-minimization analysis [17]. Under this approach, this paper tested the primary economic hypothesis of weak dominance. That is, HH showed similar safety and effectiveness than CH, but the former was less costly. The results of the current analysis were consistent with this hypothesis. The average marginal impact of the intervention (HH) in comparison with CH represented a mean cost saving of 647€ per patient ($P < 0.01$).

Limitations of the current evaluation

The economic evaluation performed in the present study may be affected by several limitations. First, the perspective of the evaluation was that of the public healthcare insurer, excluding non-health care costs. However, the short time horizon of the study (8-week follow-up) and the high cost of COPD exacerbations could be an indication of a possible small proportion of total cost for resources not included in the analysis. In this study, formal (paid work) or informal (unpaid work and leisure time) care for exacerbated COPD patients were not evaluated. Notwithstanding, a

Table 4 Expected cost per patient for different levels of disease

Patient type	Variables values according to severity levels			Predicted cost by intervention group		Savings[a]
	FEV_1	Total SGRQ score	Admissions previous year (number)	HH	CH	
Slight	70	35	1	842.4	1,300.3	457.8 (143.6–685.7)
Moderate	50	55	2	1,364.7	2,139.3	774.5 (265.7–1,143.6)
Severe	30	85	3	2,348.3	3,767.4	1,419.1 (543.5–2,054.2)
Average	41.40	49.5	0.71	1,153.7	1,800.9	647.1 (216.9–959.1)

Costs are expressed in euros at year 2000 prices. The smearing estimator has been applied

FEV1 forced expiratory volume during the first second at 8 weeks of follow-up, *Total SGRQ score* total Saint George Respiratory Questionnaire score, *HH* home hospitalization, *CH* conventional hospitalization

[a] 95% confidence interval

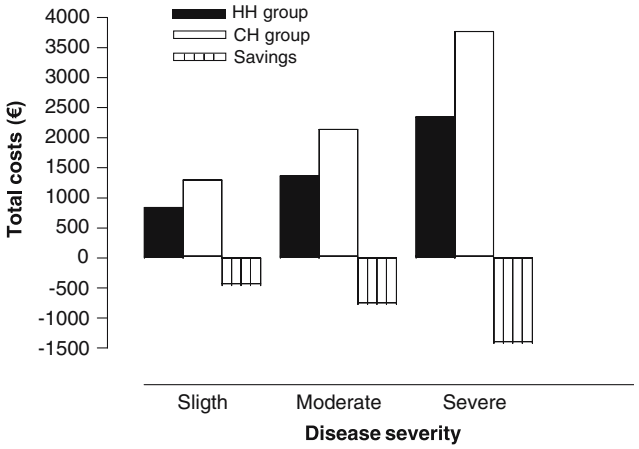

Fig. 1 Total costs predictions as expressed by different levels of disease severity. Home hospitalization intervention (*HH*) was cheaper for any level of disease severity and severely ill patients obtained largest savings. *CH* Conventional hospitalization

previous randomized controlled trial comparing hospital-at-home care with inpatient care [6] reported that carers' expenses made up a small proportion of total costs and inclusion of these costs did not alter the results.

A second limitation is that average costs were used to value hospital care. In fact, the existence of fixed hospital costs could amplify the value of any potential savings resulting from a reduction in bed-days. Another limitation related to the use of average cost to value hospital care is that normally the first days in a hospital are more expensive than the later days. A third limitation of the present evaluation comes from the fact that the clinical outcomes refer to a short-period of time, given that the time horizon is restricted to the 8-week follow-up. In fact, there is no evidence of persistence of these results over a longer period of time.

Implications for healthcare policy

In conclusion, the current study demonstrates that a well defined home-based integrated care program for the management of COPD exacerbations is of interest, even if we adopt the weak dominant alternative, as assumed in the cost minimization analysis carried out in the present analysis.

Patients assigned to HH should be assessed according to well-established criteria in order to guarantee that clinical outcomes, safety and costs of HH are maintained as promised. In this sense, the results obtained in this study only apply to the subgroup of patients with a COPD exacerbation as a major cause of referral to the ER, and in the absence of any criteria for imperative hospitalization as stated by the BTS guidelines. Also, external validity is heavily dependent on the design of the HH protocol under identical conditions to those employed in the study reported in this paper [12].

A potentially relevant policy-related implication of the current results could arise from the fact that the magnitude of resource savings under HH is higher when the intervention is applied to more severely exacerbated COPD patients. Such a statement might be controversial, and probably deserves more attention and future research. Notwithstanding, we need to point out three considerations. First, it has been well established in the clinical literature that COPD costs are positively correlated with disease severity. Then, absolute savings could be higher in the provision of efficient management of more severe COPD patients. Second, the largest savings for more severe patients could be arbitrarily imposed by the empirical specification of the cost function, given that, since the dependent variable is log-transformed, the retransformation yields an exponential increase. And, third, the result only holds for more severely exacerbated COPD patients among those eligible for the HH program, i.e., excluding some of the more severely ill COPD patients.

Hospital at home should be analyzed in the context of chronic disease care, in the so-called chronic care model [18, 19]. The identification of patients at high risk, the cooperation among primary care and specialists, the focus on social care, and the investment in information technology could improve chronic care [20]. The data of present study suggest that severe COPD patients with social support could reach the highest benefits of home-specialized care.

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