Treatment and outcomes of community-acquired pneumonia at Canadian hospitals

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Abstract

Background: Community-acquired pneumonia is a common disease with a large economic burden. We assessed clinical practices and outcomes among patients with community-acquired pneumonia admitted to Canadian hospitals.

Methods: A total of 20 hospitals (11 teaching and 9 community) participated. Data from the charts of adults admitted during November 1996, January 1997 and March 1997 were reviewed to determine length of stay (LOS), admission to an intensive care unit and 30-day in-hospital mortality. Multivariate analyses examined sources of variability in LOS. The type and duration of antibiotic therapy and the proportion of patients who were treated according to clinical practice guidelines were determined.

Results: A total of 858 eligible patients were identified; their mean age was 69.4 (standard deviation 17.7) years. The overall median LOS was 7.0 days (interquartile range [IQR] 4.0–11.0 days); the median LOS ranged from 5.0 to 9.0 days across hospitals (IQR 6.0–7.8 days). Only 22% of the variability in LOS could be explained by known factors (disease severity 12%; presence of chronic obstructive lung disease or bacterial cause for the pneumonia 2%; hospital site 7%). The overall 30-day mortality was 14.1% (95% confidence interval [CI] 11.8%–16.6%); 13.6% of the patients were admitted to an intensive care unit (95% CI 11.4%–16.1%). The median duration of intravenous antibiotic therapy was 5 days (range 3.0–6.5 days across hospitals). Although 79.8% of patients received treatment according to clinical practice guidelines, the rate of compliance with the guidelines ranged from 47.9% to 100% across hospitals.

Interpretation: Considerable heterogeneity exists in the management of community-acquired pneumonia at Canadian hospitals, the causes of which are poorly understood.

In the current fiscal environment health services providers are required to deliver the highest quality of care at the lowest possible cost. Thus, interventions that increase the efficiency of health care delivery are of critical importance. Ideally, such interventions should focus on common diseases for which a large economic burden exists and important heterogeneity in the process of care has been documented.

Community-acquired pneumonia may fit this model. This disease has an annual incidence of 12 per 1000 adults and is the sixth most common cause of death.[1] Economic analyses have indicated that about 90% of the direct medical costs of treating community-acquired pneumonia result from the provision of in-hospital care.[2,3] Previous studies have documented substantial differences among hospitals in length of stay (LOS) and use of other resources.[4,5] Although a positive correlation has been shown between LOS and disease severity, inter-hospital variations in LOS are not accountable for on this basis alone. For example, a prospective cohort study involving 552 patients at 4 US hospitals found that only a minority of the variation in LOS might be attributed to patient-related factors;[6] no relation between a longer LOS and superior patient outcomes was demonstrated. Fine and colleagues[7] speculated that these variations result from physician- and hospital-related behaviours rather than from patient-related factors.

Research

Recherche

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To assess whether similar variation is prevalent in Canadian hospitals, we evaluated the treatment and outcomes of community-acquired pneumonia at 20 hospitals across Canada.

Methods

A convenience sample of 11 teaching hospitals (defined by the geographic presence of a medical school) and 9 community hospitals across Canada participated in the study. Ethics approval was obtained from the institutional review board at the University of Western Ontario, London, Ont. All patients 18 years of age and older who were admitted to hospital in November 1996, January 1997 and March 1997 with a diagnosis of community-acquired pneumonia (codes 480–487, 507.0 and 507.8 from the clinical modification of the International Classification of Diseases, 9th revision [ICD-9-CM][8]) were evaluated for eligibility. The charts of patients whose chest x-ray report was consistent with a diagnosis of community-acquired pneumonia were retrospectively reviewed by a registered nurse who was unaware of the purpose of the study. We excluded patients with any of the following conditions: hematologic malignant disease, history of organ transplantation, tuberculosis, HIV infection, cystic fibrosis or therapy with immunosuppressant drugs. These cases were considered to represent pneumonia in an immunocompromised host and not community-acquired pneumonia. Similarly, we excluded patients who had been admitted to hospital within 10 days before the admission for pneumonia.

For eligible cases demographic characteristics, symptoms, physical findings and laboratory test results were abstracted from patient charts. These items were used to calculate the pneumonia severity index (PSI),[9] which is a valid predictor of mortality. Assuming that mortality and disease severity are correlated, we used the PSI as a measure of disease severity to explain the variation in LOS. This instrument assigns a score based on the patient's age, sex, nursing-home residence, presence of co-existing disease, physical findings and abnormal laboratory test results (Appendix 1). Scores range from about 10 to 250; higher values are found in patients with more severe pneumonia. The PSI classifies patients into 1 of 5 risk groups. Patients in risk classes I and II (score ≤ 70 points) are at low risk of death and are suitable candidates for treatment as outpatients. Patients in risk class III (score 71–90 points) are recommended for observation in the emergency department for 24 hours. Patients in risk classes IV and V (score > 90 points) are at high risk of death and should be admitted to hospital.

Selected patient characteristics, the PSI score and the hospital site were used to explain variation in LOS. Clinical outcomes of interest were the occurrence of death or admission to an intensive care unit (ICU). The 30-day in-hospital mortality was calculated because deaths that occurred after this time were considered unlikely to be due primarily to the community-acquired pneumonia.[9] The type and duration of antibiotic therapy was independently reviewed by 2 clinicians, who determined whether the course of treatment was consistent with the American Thoracic Society treatment guidelines[10] and classified the antibiotic regimen according to the class(es) of antibiotic used. Disagreements between these clinicians were resolved by consensus. LOS was measured as the number of days from admission to discharge. The analysis of LOS data excluded patients who died in hospital.[4]

Patient characteristics were summarized among teaching and community hospitals. Median LOS, admission to ICU and 30-day in-hospital mortality were summarized by PSI risk class. Multiple linear regression analyses were performed to examine the amount of variation in LOS that could be explained by disease severity (PSI), additional patient characteristics that were not components of the PSI and the hospital site. The PSI scores were included in the analyses in 3 ways: as continuous variables, as indicator variables for the PSI risk classes and as individual components that were significantly associated with LOS. Additional patient characteristics examined included smoking status, presence of asthma or chronic obstructive pulmonary disease, and laboratory confirmation of bacterial pneumonia (positive blood or sputum culture). Although these factors are not incorporated into the PSI, we included them in our evaluation because of their perceived clinical importance. Three regression models were generated. In step 1, only disease severity (PSI) was entered. In step 2, additional patient characteristics found to be significantly associated with LOS in univariate analyses ($p < 0.10$) were added. In step 3, indicator variables of the hospital sites were added. The R^2 value, a measure of the amount of variation in LOS potentially explained by the variables in the model, was calculated for each model. Because the distribution of LOS was highly skewed to the right by a few long hospital stays, a logarithmic transformation was applied.[11]

Results

A total of 1113 cases were identified from the medical records at the 20 hospitals. We excluded 255 cases; the most common reasons for exclusion were immunosuppressive drug therapy (149 cases) and admission to hospital within 10 days before the current admission (68 additional cases). This left 858 eligible cases of community-acquired pneumonia.

Table 1 shows the characteristics of the eligible patients by type of hospital (teaching or community). The mean age was 69.4 (range 18–99) years. The mean PSI score was 105.0 (range 9–244) points, and the proportion of patients classified as high risk (PSI classes IV and V) was 61.9%.

The clinical outcomes according to PSI class and hospital site are presented in Table 2. Overall 13.6% of the patients were admitted to an ICU (95% confidence interval [CI] 11.4%–16.1%). The overall 30-day in-hospital mortality was 14.1% (95% CI 11.8%–16.6%). The mortality ranged from 0% to 40.0% across hospitals; the highest rate occurred at the hospital with the fewest beds and the least number of cases of community-acquired pneumonia (10 cases). Neither the mortality nor the ICU admission rate differed significantly between the community and teaching hospitals. The PSI class showed a positive correlation with all of the outcomes: patients with more severe disease were more likely to be admitted to an ICU, were at increased risk of death and had a longer LOS. Overall 19.4% (161/830) of the patients were classified as low risk (PSI classes I and II) (range 5.7%–40.0% across hospitals).

Considerable heterogeneity in LOS was noted among the hospitals (Table 2). The overall median LOS was 7.0 days (interquartile range [IQR] 4.0–11.0 days); the median LOS ranged from 5.0 to 9.0 days across hospitals (interquartile range [IQR] 6.0–7.8 days). No significant differences in LOS

were observed between the teaching and community hospitals (median LOS 7.0 days in both groups).

The results of the regression analyses showed that only 12% of the variation in LOS might be explained by disease severity as measured by the PSI score. An additional 2% was associated with the presence of either chronic obstructive pulmonary disease or the demonstration of bacterial pneumonia by laboratory cultures. Finally, an additional 7% of the variation was associated with the hospital site. The alternative modelling using the PSI components or PSI classes to represent disease severity yielded similar findings.

Table 3 shows the data regarding the use of antibiotics. The median duration of intravenous antibiotic therapy was 5.0 days (range 3.0–6.5 days across hospitals). The most frequently prescribed antibiotic regimen (in 32% of cases) consisted of a β-lactam drug as monotherapy. The combination of a β-lactam drug and macrolide was the next most prevalent treatment protocol (in 30% of cases). Although

Table 1: Characteristics of patients with community-acquired pneumonia admitted to hospital

Characteristic	Type of hospital; % of patients (and 95% CI)*		
	Teaching hospital *n = 573*	Community hospital *n = 285*	All *n = 858*
Demographic characteristics			
Age, yr			
Mean (and SD)	69.4 (17.7)	69.3 (17.8)	69.4 (17.7)
95% CI	67.9–70.8	67.2–71.4	68.2–70.5
Male	54.3 (50.1–58.4)	52.1 (46.1–58.0)	53.6 (50.2–57.0)
Nursing-home resident	18.4 (15.3–21.9)	12.0 (8.5–16.4)	16.3 (13.9–19.0)
Co-existing illnesses			
Neoplastic disease	9.9 (7.6–12.7)	9.1 (6.0–13.1)	9.7 (7.8–11.9)
Liver disease	1.9 (1.0–3.4)	1.4 (0.4–3.6)	1.7 (1.0–2.9)
Congestive heart failure	22.3 (19.0–26.0)	20.7 (16.1–25.9)	21.8 (19.1–24.7)
Cerebrovascular disease	11.9 (9.3–14.8)	9.5 (6.3–13.5)	11.1 (9.1–13.4)
Renal disease	7.0 (5.0–9.4)	6.3 (3.8–9.8)	6.8 (5.2–8.7)
Physical examination findings			
Altered mental state	27.1 (23.5–30.9)	24.2 (19.4–29.6)	26.1 (23.2–29.2)
Respiratory rate ≥ 30 breaths/min	22.0 (18.7–25.6)	25.0 (20.0–30.5)	23.0 (20.2–26.0)
Systolic blood pressure < 90 mm Hg	5.6 (3.9–7.8)	5.3 (3.0–8.5)	5.5 (4.1–7.2)
Temperature < 35°C or ≥ 40°C	6.0 (4.2–8.2)	3.3 (1.5–6.1)	5.1 (3.7–6.8)
Pulse ≥ 125 beats/min	14.2 (11.4–17.3)	14.6 (10.7–19.3)	14.3 (12.0–16.9)
Laboratory and radiographic findings			
Arterial blood pH < 7.35	11.3 (8.9–14.2)	8.8 (5.8–12.7)	10.5 (8.5–12.7)
Blood urea nitrogen level ≥ 30 mg/dL (11 mmol/L)	26.5 (23.0–30.3)	13.0 (9.3–17.4)	22.0 (19.3–25.0)
Sodium level < 130 mmol/L	9.2 (7.0–11.9)	4.6 (2.5–7.7)	7.7 (6.0–9.7)
Glucose level ≥ 250 mg/dL (14 mmol/L)	9.8 (7.5–12.5)	8.4 (5.5–12.3)	9.3 (7.5–11.5)
Hematocrit < 30%	11.4 (8.9–14.4)	9.0 (5.8–13.1)	10.6 (8.6–12.9)
Partial pressure of arterial oxygen < 60 mm Hg or oxygen saturation < 90%	45.2 (41.1–49.4)	31.6 (26.2–37.3)	40.7 (37.4–44.0)
Pleural effusion	27.8 (24.1–31.7)	20.3 (15.4–26.0)	25.5 (22.5–28.7)
Pneumonia severity index (PSI) score†			
Mean (and SD)	106.8 (40.7)	100.8 (40.1)	105.0 (40.6)
95% CI	103.3–110.4	95.5–106.1	102.1–108.0
PSI class IV or V,‡ % of patients (and 95% CI)	64.7 (60.6–68.6)	56.0 (49.9–62.0)	61.9 (58.5–65.2)
Chronic lung disease, % of patients (and 95% CI)	27.6 (24.0–31.4)	37.9 (32.2–43.8)	31.0 (27.9–34.2)
Bacterial cause of pneumonia, % of patients (and 95% CI)	24.5 (21.0–28.2)	19.5 (15.0–24.7)	22.8 (20.0–25.8)

Note: SD = standard deviation, CI = confidence interval.
*Unless stated otherwise.
†PSI scores range from about 10 to 250; higher scores indicate more severe disease.
‡Patients in these classes are at substantial risk of death (PSI score > 90).

most patients (79.8%) were treated according to American Thoracic Society treatment guidelines[10] the rate of compliance with these recommendations ranged from 47.9% to 100% across hospitals.

Interpretation

This study shows significant heterogeneity in the management of patients with community-acquired pneumonia. The median LOS ranged from 5.0 to 9.0 days among a sample of 20 Canadian hospitals. Only 22% of this variation could be attributed to disease severity or other identifiable patient or hospital factors. These results are similar to those reported by Fine and colleagues,[6] who could attribute only 24% of the variation in LOS at 4 US hospitals to known factors. Similarly, important heterogeneity among institutions was observed in the duration of intravenous antibiotic therapy and adherence to treatment guidelines. These practice variations are surprising for a disease that is common, has a well-characterized natural history and for which effective drug therapies have been identified. The variations probably represent a source of increased cost to hospitals that is not associated with improved outcomes. Because the cost of treatment for community-acquired pneumonia is about $1000 per day,[2,3] interventions to reduce practice variation may yield important savings.

A number of interventions may increase the efficiency of patient management. Fine and colleagues[9] developed the PSI as a clinical prediction rule to aid in the admission decision and suggested that low-risk patients be treated in the community. In the only study that has evaluated this possibility, Atlas and associates[12] found that the rate of admission among these patients was 15% lower during a period when the PSI was used than during a historical control interval. However, we believe that further randomized controlled studies are required before this

Table 2: Clinical outcomes of patients by PSI class and hospital

Variable	No. of patients	Outcome; % of patients (and 95% CI)		
		Admission to ICU	30-day in-hospital mortality	Median length of stay (and IQR)
PSI class*				
I–II	161	7.5 (3.9–12.7)	0.0 (0.0–2.3)	5.0 (3.0–7.5)
III	150	9.4 (5.2–15.3)	3.3 (1.1–7.6)	6.0 (4.0–8.0)
IV–V	519	17.0 (13.9–20.5)	22.4 (18.8–26.2)	8.0 (5.0–13.0)
Teaching hospitals				
T1	74	8.2 (3.1–17.0)	14.9 (7.7–25.0)	7.0 (5.0–12.0)
T2	71	24.3 (14.8–36.0)	18.3 (10.1–29.3)	6.0 (4.0–11.0)
T3	70	8.6 (3.2–17.7)	18.6 (10.3–29.7)	6.0 (4.0–9.0)
T4	66	19.7 (10.9–31.3)	10.6 (4.4–20.6)	7.0 (6.0–13.0)
T5	61	16.4 (8.2–28.1)	14.8 (7.0–26.2)	7.5 (4.0–14.0)
T6	60	10.0 (3.8–20.5)	18.3 (9.5–30.4)	5.0 (3.0–8.0)
T7	53	0.0 (0.0–6.7)	11.3 (4.3–23.0)	5.0 (3.0–8.0)
T8	49	20.8 (10.5–35.0)	16.3 (7.3–29.7)	8.0 (5.0–13.0)
T9	38	7.9 (1.7–21.4)	10.5 (2.9–24.8)	6.5 (4.0–13.0)
T10	17	0.0 (0.0–19.5)	5.9 (0.1–28.7)	6.5 (4.5–8.5)
T11	14	7.1 (0.2–33.9)	0.0 (0.0–23.2)	9.0 (6.0–10.0)
Subtotal	*573*	*12.7 (10.0–15.7)*	*14.5 (11.7–17.6)*	*7.0 (4.0–11.0)*
Community hospitals				
C1	63	5.1 (1.1–14.1)	9.5 (3.6–19.6)	6.0 (4.0–9.0)
C2	46	21.7 (10.9–36.4)	8.7 (2.4–20.8)	8.0 (5.0–12.0)
C3	42	9.5 (2.7–22.6)	9.5 (2.7–22.6)	6.0 (5.0–9.0)
C4	35	31.4 (16.9–49.3)	14.3 (4.8–30.3)	8.0 (5.0–11.0)
C5	34	14.7 (5.0–31.1)	5.9 (0.7–19.7)	7.5 (4.0–13.0)
C6	23	26.1 (10.2–48.4)	30.4 (13.2–52.9)	7.0 (4.0–8.0)
C7	16	12.5 (1.6–38.3)	12.5 (1.6–38.3)	8.0 (3.0–15.0)
C8	16	12.5 (1.6–38.3)	25.0 (7.3–52.4)	6.0 (4.0–10.5)
C9	10	10.0 (0.3–44.5)	40.0 (12.2–73.8)	6.5 (4.0–25.0)
Subtotal	*285*	*15.7 (11.6–20.4)*	*13.3 (9.6–17.8)*	*7.0 (4.0–10.0)*
Total	858	13.6 (11.4–16.1)	14.1 (11.8–16.6)	7.0 (4.0–11.0)

Note: IQR = interquartile range.
*PSI classes I and II = score of ≤ 70; class III = score of 71–90; classes IV and V = score of ≥ 91.

instrument can be accepted into clinical practice.

Other interventions include the expanded use of oral antibiotic therapy,[13] prompt conversion from intravenous to oral therapy[14] and the application of uniform discharge criteria.[15] Although the incorporation of such interventions into practice guidelines might decrease the variation in LOS, randomized controlled trials are required to assess definitively the safety and cost-effectiveness of such programs.[15]

Current Canadian health care policy could also be contributing to the variation in LOS. Patients may remain in hospital to gain access to medical services that are not easily obtainable in the outpatient setting. Similarly, the restrictions on the availability of home care services and nursing-home beds may also increase LOS.[16]

We found that most (79.8%) of the patients were treated according to American Thoracic Society guidelines.[10] This estimate is similar to those reported by others.[17] However, the rate of compliance with the guidelines varied from 47.9% to 100% across the hospitals studied. Similarly, the median duration of intravenous antibiotic therapy differed among the hospitals by more than 3 days. These variations provide an opportunity to reduce treatment costs by defining optimal clinical practices.

Notable limitations of any retrospective study, such as this chart review, are incomplete data and the potential for bias. However, the influence of these factors in our study were minimal. The LOS, rate of admission to ICU and mortality are highly objective endpoints that were available for all of the patients. Similarly, the identification of cases of community-acquired pneumonia was probably free from ascertainment bias because a clinical diagnosis based on an ICD-9-CM code and a confirmatory chest x-ray were used. Furthermore, all cases were reviewed by a nurse who discussed any questionable cases with a physician. This degree of scrutiny is much greater than that which would occur if data from an administrative source were used. Thus, we believe our observations and conclusions regarding institutional variation are accurate despite the retrospective design.

In summary, we have shown that considerable heterogenity exists in the management of community-acquired pneumonia in Canadian hospitals. The causes of this variation are poorly understood and require further evaluation. Interventions to improve the efficiency of health care delivery and outcomes seem warranted.

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Table 3: Use of antibiotic therapy during hospital stay

Variable	No. of patients	Median duration of IV therapy, d	ATS guidelines followed, % of patients	No. of drug classes, % of patients			
				1	2	3	> 3
Teaching hospitals							
T1	74	5.0	82.2	39.7	47.9	8.2	4.1
T2	71	5.0	47.9	16.9	69.0	8.5	5.6
T3	70	4.0	79.7	55.1	27.5	13.0	4.3
T4	66	5.0	90.9	47.7	36.9	13.8	1.5
T5	61	4.5	81.7	38.3	41.7	20.0	0.0
T6	60	4.0	86.7	42.4	42.4	11.9	3.4
T7	53	3.0	83.0	40.4	44.2	13.5	1.9
T8	49	5.0	83.3	43.8	45.8	8.3	2.1
T9	38	6.0	94.7	28.9	55.3	13.2	2.6
T10	17	6.0	82.4	11.8	76.5	11.8	0.0
T11	14	6.0	64.3	35.7	42.9	21.4	0.0
Subtotal	*573*	*5.0*	*79.6*	*38.5*	*46.3*	*12.4*	*2.8*
Community hospitals							
C1	63	6.0	89.7	53.4	43.1	1.7	1.7
C2	46	6.0	80.4	28.9	57.8	6.7	6.7
C3	42	5.0	81.0	38.1	47.6	14.3	0.0
C4	35	5.5	85.7	31.4	62.9	5.7	0.0
C5	34	5.0	51.5	33.3	57.6	9.1	0.0
C6	23	6.0	78.3	39.1	56.5	4.3	0.0
C7	16	5.0	62.5	37.5	37.5	25.0	0.0
C8	16	5.0	100.0	40.0	46.7	13.3	0.0
C9	10	6.5	100.0	70.0	20.0	10.0	0.0
Subtotal	*285*	*5.0*	*80.2*	*39.7*	*50.5*	*8.3*	*1.4*
Total	858	5.0	79.8	38.9	47.7	11.0	2.4

Note: ATS = American Thoracic Society.

Competing interests: None for Ms. Wong. Dr. Feagan has received speaker fees from Janssen–Ortho Inc. Dr. Marrie has served on advisory boards of Janssen–Ortho Inc., Pfizer Inc. and Glaxo-Wellcome, and he has received speaker fees from various organizations including Janssen–Ortho Inc., Pfizer Inc. and Glaxo–Wellcome. Dr. Lau and Ms. Wheeler are employed by Janssen–Ortho Inc. and have received stock and stock options from the company. Ms. Vandervoort has received travel assistance from Janssen–Ortho Inc. to attend a meeting to present project management issues of an earlier study.

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Appendix 1: Point scoring system for the pneumonia severity index

Characteristic	Points assigned*
Demographic factor	
Age	
Men	Age (yr)
Women	Age (yr) – 10
Nursing-home resident	+10
Co-existing illnesses†	
Neoplastic disease	+30
Liver disease	+20
Congestive heart failure	+10
Cerebrovascular disease	+10
Renal disease	+10
Physical examination findings	
Altered mental status‡	+20
Respiratory rate ≥ 30 breaths/min	+20
Systolic blood pressure < 90 mm Hg	+20
Temperature < 35°C or ≥ 40°C	+15
Pulse ≥ 125 beats/min	+10
Laboratory and radiographic findings	
Arterial blood pH < 7.35	+30
Blood urea nitrogen level ≥ 30 mg/dL (11 mmol/L)	+20
Sodium level < 130 mmol/L	+20
Glucose level ≥ 250 mg/dL (14 mmol/L)	+10
Hematocrit < 30%	+10
Partial pressure of arterial oxygen < 60 mm Hg or oxygen saturation < 90%	+10
Pleural effusion	+10

*A total point score for a given patient is obtained by summing the patient's age in years (age minus 10 for women) and the points for each applicable characteristic. The points assigned to each predictor variable were based on coefficients obtained from the logistic regression model used in step 2 of the prediction rule.

†Neoplastic disease is defined as any cancer except basal- or squamous-cell cancer of the skin that was active at the time of presentation or diagnosed within 1 year of presentation. Liver disease is defined as a clinical or histologic diagnosis of cirrhosis or another form of chronic liver disease, such as chronic active hepatitis. Congestive heart failure is defined as systolic or diastolic ventricular dysfunction documented by history, physical examination, and chest radiograph, echocardiogram, multiple gated acquisition scan or left ventriculogram. Cerebrovascular disease is defined as a clinical diagnosis of stroke or transient ischemic attack or stroke documented by MRI or CT scanning. Renal disease is defined as a history of chronic renal disease or abnormal blood urea nitrogen and creatinine concentrations documented in the medical record.

‡Altered mental status is defined as disorientation with respect to person, place, or time that is not known to be chronic, stupor or coma.

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