SUPPLEMENT ARTICLE

Telemedicine: The Future of Outpatient Therapy?

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Early hospital discharge of acutely infected patients to received outpatient parenteral antimicrobial therapy has been shown to be safe and effective. However, concerns over safety, potential litigation, and anxieties of the patient and family about not receiving professional care have limited the use of this approach. Telemedicine may overcome these barriers by allowing health care providers to monitor and communicate with acutely infected patients from a remote medical center via a home computer station transmitting audio, video, and vital signs data. Potential benefits of telemedicine include significant cost savings and faster convalescence, because patients at home may feel more comfortable and actively involved in their treatment than patients in the hospital. Clinical studies have shown that telemedicine is safe and cost-effective, compared with hospital treatment, in chronically ill and acutely infected patients. More studies are needed to further establish the widespread and increasing practice of telemedicine, which may represent the future of medicine.

Early hospital discharge to use of outpatient parenteral antimicrobial therapy (OPAT) has been shown to be both safe and effective for the treatment of acutely infected patients [1–5]. Conditions frequently treated in this manner include community-acquired pneumonia (CAP), skin and soft-tissue infection, urinary tract infection, and bacterial endocarditis. However, OPAT alone is not recommended for some patients with severe illness or complications, including those who must be monitored several times per day because of comorbidities and/or low performance scores [6]. Furthermore, the decision to discharge a patient to OPAT or to discharge a patient who has been switched to oral antibiotics may be delayed because of persistent fever or simply for a day of observation [4, 7, 8]. Routine in-hospital observation after the oral switch is no longer considered to be necessary or justifiable. However, a survey of physicians responsible for deciding whether to discharge patients with CAP revealed that the most important factors defining clinical stability that supported the decision to discharge the patient included normal temperature; return to baseline respiratory status, mental status, and oxygenation; and the ability to maintain oral intake of antibiotics [9]. The survey respondents also believed that >20% of patients remained in the hospital beyond the point at which they had reached clinical stability. The most frequently cited services that would definitely or probably have allowed earlier hospital discharge were home intravenous antimicrobial treatment, home visits by nurses, and home visits by physicians.

Early discharge may also present problems for patients who are still sick and, therefore, anxious about not receiving professional care and for family members who may be equally anxious about the patient's safety and intimidated by their responsibility for his or her treatment. Physicians may also have some trepidation about discharging patients to home before they are clinically stable because of safety issues and the ever-present problem of potential litigation. Discharge to home from the emergency department or early in the course of hospitalization of febrile, acutely infected patients is now possible through the use of telemedicine [10].

TELEMEDICINE

The first formal and published definition of telemedicine was "the practice of medicine without the usual physician-patient confrontation…via [an] interactive audio-video communication system" [11, p 614]. This definition was soon expanded to include the concept

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of telehealth, "a broad range of health-related activities, including patient and provider education, and health services administration, as well as patient care" [11, p 614]. Currently, every state has at least one telemedicine program. Some are statewide, offer a comprehensive range of clinical services and continuing education, and involve a large number of hospitals and clinics.

According to a 1997 survey of all nonfederal rural hospitals in the United States [12], ~1 in 4 had telemedicine programs, although almost two-thirds were teleradiology. These applications have led to the hub-and-spoke concept, whereby rural hospitals are connected to tertiary care centers by telemedicine. To date, ~200 such networks are operating in the United States, linking >3500 institutions nationwide [13].

Transmission of video images, audio, and vital signs data from a remote site to a central location has been used in homes to monitor chronically ill patients, including those with congestive heart failure, chronic obstructive pulmonary disease, and diabetes mellitus [10]. In a home health care study by a nonprofit health maintenance organization, chronically ill patients who were eligible for home health care were offered either routine in-person and phone visits or the routine program and telemedicine visits [14]. Routine care included initial assessment in the home and in-person follow-up by nurses, as well as the ability of the patient to reach a home health nurse by phone from 8:30 AM through 5:00 PM for additional information or triage. Additional verbal contact after normal working hours was available through the hospital's telephone advice center or at the emergency department. Patients also had the option of being transported to an emergency department or urgent care clinic for assessment if necessary.

The telemedicine intervention group had access to a home health nurse 24 h per day; an on-call home health nurse could contact the patient using the remote video equipment, which allows in-depth assessment and triage without patients having to leave home [14]. Installation of the home video system and instruction of the patient in its use required ~30 min. Peripheral units of the system included an analog stethoscope and a digital blood pressure machine; thus, nurses at the hospital site were able to assess cardiopulmonary status, evaluate bowel sounds, and view facial expression and signs of infection. A magnifying lens that attached to the camera was used to assess correct medication doses when patients were being taught how to use medications, such as insulin.

No differences in the quality indicators (ie, medication compliance, knowledge of disease, and ability for self care), patient satisfaction, or use were seen. Moreover, the video technology in the home health care setting yielded mean cost savings per patient, although the savings were less than expected because the intervention included the full cost of equipment and telecommunications start-up; in practice, the equipment would be leased or amortized over several years. The investigators concluded that telemedicine can be an asset for patients and providers and has the potential to reduce costs [14]. However, these results are based on a nonrandomized, case-control study, which could have introduced biases into the conclusions.

TELEMEDICINE AND ACUTE CARE

Adaptation of telemedicine to the home care of acutely infected patients who would normally be hospitalized was introduced in a 2004 pilot study comparing 25 moderately to severely ill patients treated by telemedicine in the home with a control group that remained in the hospital [10]. The study was at least partially based on a 2001 observational study that challenged the conventional hospital discharge process for patients admitted with an acute infection [4]. According to this process, patients undergo 3 stages of recovery from a severe infection (Figure 1). Stage 1 extends from admission to clinical stability, implying that the condition of the patient is no longer worsening and has thus stabilized [10], and stage 2 devolves to early improvement, suggesting a trend toward normality of temperature and other inflammatory indicators. By the end of stage 3, which represents normalization of most clinical parameters, the patient is sufficiently healthy to be discharged. The outcomes in acutely infected patients with cellulitis, CAP, and urinary tract infection who were discharged after defervescence and definite clinical improvement were compared with those in similarly infected patients discharged while still febrile (Figure 2) [4]. In addition to a shorter mean length of hospital stay, patients discharged early returned to normal activities of daily living more rapidly than did those whose discharge required a return of normal temperature.

In the 2004 study, patients with CAP, skin and soft-tissue infections, urinary tract infection, and bacterial endocarditis were referred from either the emergency department or the hospital for telemedicine in the home [10]. Inclusion criteria included a home with a person to assist the patient, willingness to self-administer intravenous antibiotics when necessary, and a low predicted 30-day mortality rate. Patients had to be ill

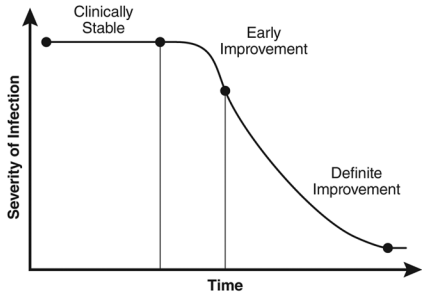

Figure 1. Three stages of recovery from infection, from clinical stability to definite improvement and hospital discharge.

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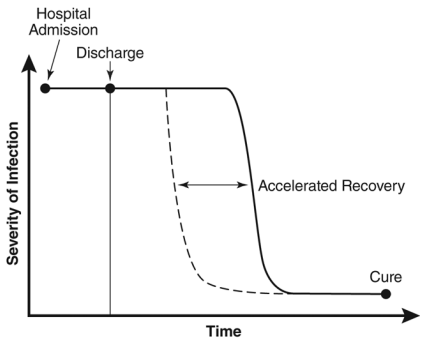

Figure 2. Course of selected patients discharged to home telecare shortly after hospital admission, often while still febrile, resulting in more rapid return to recovery and cure.

enough to require hospitalization but not intensive care monitoring. These patients were not conventional home-care or OPAT candidates. All were screened for severity of illness, and those with mild or life-threatening infections were excluded. Of 41 patients evaluated using the Karnofsky performance scale [15] and the Charlson comorbidity index [16, 17], 25 were candidates for telemedicine in the home. Examples of the types of treated patients are shown in Table 1 [10].

The Karnofsky performance scale measures a patient's ability to perform activities of daily living from 100% (ie, normal, no complaints, and no evidence of disease) to 10% (ie, moribund, with fatal processes progressing rapidly) and 0% [15]. The Charlson comorbidity index, originally designed to classify prognostic comorbidity in longitudinal studies, uses age and specific comorbidities to predict survival [16, 17]. The score is calculated for each patient as the total of the patient's comorbid conditions, which are weighted. Thus, a patient with moderately severe CAP may have a high pneumonia severity index but can still be treated as an outpatient if he or she has a reasonably high Karnofsky score of 80% (ie, normal activity with effort and some signs and symptoms of disease). The opposite is also true: a patient with mild CAP and a low pneumonia severity index may be at high risk on the basis of a low Karnofsky score and a number of comorbidities.

Telemedicine equipment consisted of an Aviva Tower central station and 4 Aviva 1010 XR patient stations, with a station kept in reserve [18]. The connection between each patient's home station and the central station in the hospital was through plain old telephone service lines. The telemedicine team included a physician, 2 nurse practitioners, an information technology consultant, and a project coordinator.

After discharge from the hospital, telemedicine candidates were met in the home by a member of the telemedicine team who had transported the patient's telemedicine equipment, or station [10]. Installment of the station required a nearby telephone outlet, through which the audiovisual and vital signs were transmitted, and adequate lighting. A second member of the team, a nurse practitioner or physician, communicated with the patient from a central station at the hospital (Figure 3) [10].

Eight patients started home telemedicine without being hospitalized; 12 had been hospitalized for ≤4 days, and 5 had been hospitalized for 5–10 days before discharge. The mean number of combined hospital and home televisit days (8.3 days) was similar to the mean duration of hospitalization (8.0 days) in the control group.

None of the telemedicine patients had to be rehospitalized, although 3 had recurrent infections. Three control patients had recurrent CAP, and 1 of these patients was readmitted to the hospital. A fourth control patient experienced nosocomial *Clostridium difficile* enterocolitis. Patients receiving telemedicine returned to normal activities of daily living several weeks earlier than did control subjects (Table 2) [10].

TELEMEDICINE COSTS

On the basis of the projected enrollment of 50 patients by the end of 1 year, the number of hospital-days for control subjects (8 days) and patients receiving telemedicine (2.8 days), and the hypothesis that each telemedicine-day equals 1 hospital-day saved [10], the trial investigators calculated that telemedicine would have saved up to 5.2 days (range, 2.8–8.0 days) of hospitalization for each patient treated, or 260 (5.2×50) patient-days per year. Because the cost of a hospital bed is \$500–\$2000 per day, the pilot trial would have saved \$130,000–\$520,000 in one year.

The cost of equipment (amortized over 2 years), personnel, and information technology consultation amounted to \$120,000. Thus, the program would have netted \$10,000–\$400,000 in 1 year [10].

TELEMEDICINE REIMBURSEMENT

Medicare

Clinical services. Although the Balanced Budget Act of 1997 mandated that Medicare reimburse telemedicine services to physicians on a fee-for-service basis, it also required the presence of a Medicare-participating telepresenter (a clinician at the patient end of the televisit) [19]. This mandate, in addition to the limitations on the telecommunications infrastructure in remote or hostile environments, meant that only live telemedicine services (10% of the total) were cost-effective. Moreover, an additional requirement that the telepresenter and the consulting physician share the fee suggested the potential for violating Medicare's own prohibition against payment for referrals.

The 2000 omnibus appropriations bill HR 5661 dramatically revised Medicare rules for reimbursement as of 1 October 2001. The revisions included elimination of the requirement for a Medicare-participating telepresenter; expansion of telemedicine services to include direct patient care, physician consultations,

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Table 1. Representative Patients Treated by Home Telecare

Condition	Patient	Course and outcome
Community-acquired pneumonia	A 78-year-old man with leukemia and an absolute neutrophil count of 400 neutrophils/mm^3 who developed bibasilar infiltrates, a temperature of 38.8°C, and an oxygen saturation of 90%	Recovered rapidly while receiving intravenous cefepime and oral moxifloxacin, using telemedicine in the home
Skin and soft-tissue infection	A 48-year-old woman with metatastic carcinoma of the breast and a white blood cell count of 2500 cells/mm^3 who developed cellulitis extending from her hip to her axilla	Received intravenous ceftriaxone and recovered uneventfully using telemedicine in the home
Urinary tract infection	A morbidly obese 53-year-old man with a mechanical aortic valve prosthetic who developed high-grade enterococcal urosepsis (5 of 5 blood culture and urine culture results were positive)	A transesophageal echocardiogram did not reveal vegetations on the aortic valve, and the patient was treated successfully with 6 weeks of ampicillin and gentamicin using home telemedicine; although classified as urinary tract infection, it may have been bacterial endocarditis
Bacterial endocarditis	A 66-year-old man with severe aortic insufficiency and a previous right-side nephrectomy for a renal cell carcinoma who developed Gemella endocarditis with a vegetation on his aortic valve	Successfully treated with ceftriaxone using telemedicine in the home

Reprinted from [10].

and office psychiatry services; payment for physicians or practitioners at distant sites at rates generallly applicable to services; expansion of originating site definition to include physician and practitioner offices, critical access hospitals, rural health clinics, and federally qualified health centers and hospitals, with exclusion of nursing homes; and expansion of originating sites to include rural areas outside the medical service area where there are shortages of health professionals [19].

Home care. Medicare's Prospective Payment System provides a fixed payment for each Medicare beneficiary for a 60-day period on the basis of the assigned Home Health Resource Group, which in turn provides a fixed payment for an unlimited number of medically necessary episodes of care [20]. The per-episode payment covers all skilled nursing visits, home health aide visits, physical therapy, occupational therapy, speech pathology, medical social services, and nonroutine medical supplies. Payment is adjusted according to the number of necessary visits, which reflects severity of illness.

The Prospective Payment System creates an incentive for home health providers to proactively manage the delivery of care and to use innovative means to deliver care while reducing costs. When costs are lower than Medicare payment rates, providers are entitled to retain the difference as a profit. Although HR5661 specifically permits the use of telemedicine services to satisfy home health care delivery obligations under the Prospective Payment System, telemedicine visits do not constitute a visit under the Outcome Assessment and Information Set evaluation tool [21] for purposes of determining assignment to a Home Health Resource Group. Therefore, home care providers should assess the benefits of telemedicine services and the effect that substitution of telemedicine visits will have on reimbursement in accordance with the Medicare Prospective Payment System.

Medicaid

Many states that struggle to find cost-effective ways to provide care and to seek reducing geographic and provider-network barriers have considered telemedicine programs. However, not all states have embraced this technology, in part because of significant challenges involving service reimbursement. State Medicaid programs vary with regard to whether they provide telemedicine and how they structure it. A nationwide survey of Medicaid programs regarding telemedicine services was published in 2005 [22]. Although focused on children with special health care needs, the survey's first goal was to identify common strategies related to Medicaid reimbursement.

Among the 50 states surveyed, Medicaid programs in 24 states reported that they reimburse for telemedicine, and programs in 4 were planning to implement reimbursement in the future [22]. All 24 programs reimbursed for some physician consultations via video teleconferencing; 19 reimbursed for real-time consultations only, and of these, 3 specified that the patient must be present at the time of consultation. The most common reimbursable services are medical and behavioral and/or mental health diagnostic consultations or treatments. Limitations on service included reimbursement for behavioral and/or mental health only (1 state), no reimbursement for mental health (1), no reimbursement for ancillary services (2), reimbursement only when the spoke site is in the hospital emergency department or outpatient setting (1), and reimbursement only to clients enrolled in fee-for-service Medicaid (3). Licensed physicians are reimbursed in all 24 states. In general, any pro-

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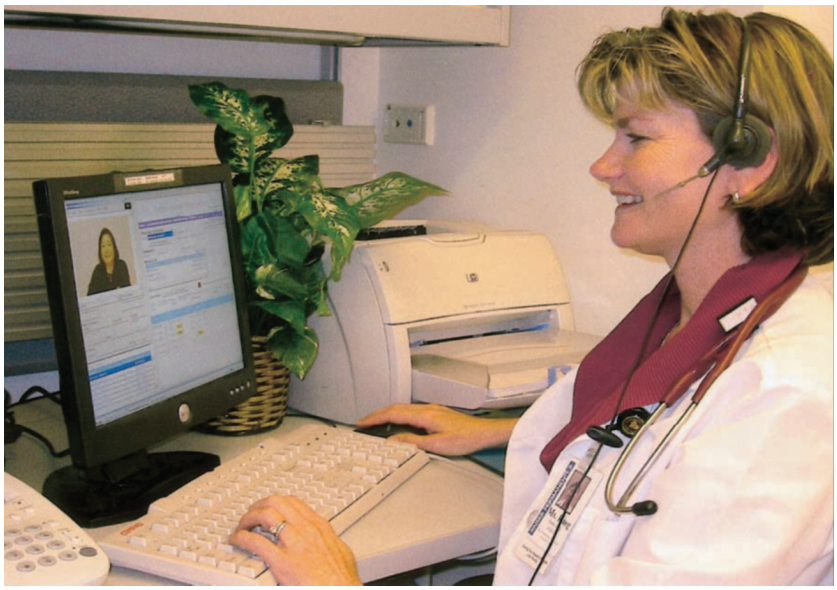

Figure 3. A home televisit from the central station. Reprinted from [10].

vider who billed for face-to-face visits could bill for telemedicine. All 24 states reimbursed in accordance with fee-for-service arrangements.

Twenty-two states reported that Medicaid does not reimburse, including 1 state that discontinued telemedicine reimbursement after determining that it was not cost-effective [22]. Medicaid programs in 4 of the 22 states have ongoing pilot projects and expressed the intent to establish a reimbursement program.

Commercial Insurers

Payment policies for telemedicine services vary widely among commercial insurers [19]. An organization may have the leverage to require payment for such services as a condition to enter a contract before negotiation. On the other hand, contracts that do not specifically provide for payments for telemedicine services may incorporate reference to Medicare for coverage of services rules. Finally, it is advisable to consult with legal counsel or contracting specialists to determine whether contracts provide, directly or indirectly, for reimbursement.

The recognition of telemedicine visits as allowable visits for reimbursement varies among insurers [19]. Many are interested in demonstration projects to provide treatment to chronically ill patients, and some allow payment for telemedicine-based equipment in the home.

Although the lack of private payer reimbursement has been seen as a major barrier to the acceptance and growth of telemedicine, a 2003 survey of members of the American Telemedicine Association found that 38 of 72 programs were receiving reimbursement from private payers [23]. At that time, payers were reimbursing in at least 25 states. Moreover, in many cases, payers were following the lead of Blue Cross/Blue Shield rather than Medicaid and/or Medicare.

As of 2000, 5 states (California, Kentucky, Louisiana, Oklahoma, and Texas) had passed legislation mandating private payer reimbursement for telemedicine services [23]. For example, Oklahoma's SB 48 (1997) provides that health care plans cannot deny coverage for health care services provided through audio, video, or data communications. This would allow compensation for patient consultations, diagnoses, and the transfer of medical data through telecommunication technology. The measure excludes telephone and facsimile communications from the term "telemedicine." Kentucky's HB 177 (2000) prohibits Medicaid and private insurers from requiring face-to-face contact between a health care provider and patient for services appropriately provided through telemedicine, subject to the terms of the contract.

A follow-up survey in 2007 found that at least 35 states were receiving Medicaid reimbursement for telemedicine services, with the same mandates in the same 5 states [24]. A total of 116 telemedicine programs were identified, with a 55% response rate. Of the 64 respondents, 61 provide billable services and 58% receive private pay (42% do not). The percentage of programs receiving private payer reimbursement increased by 5% from 2003. The majority of programs (81%) reported no difference in the amount of reimbursement between telemedicine services and traditional consultations.

TELEMEDICINE ISSUES

For telemedicine in the home to enter the conventional medical care network, 4 major issues must be examined: technical prob-

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Table 2. Comparison of Patients Treated by Home Telecare and by Hospitalization

Outcome	Telemedicine group	Hospitalized control group	*P*
No. of patients with unsuccessful clinical outcome	3	4	.30[a]
Satisfaction level			
Comfort	4.9[b]	3.0[b]	.35[c]
Safety	3.8[b]	4.7[b]	.09[c]
Time to return to activities of daily living, mean days[d]	8	21	<.001[c]

NOTE. Reprinted from [10].

[a] By the Fisher exact test.

[b] Five-point scale: 5, very positive; 4, mildly positive; 3, neutral; 2, mildly negative; and 1, very negative.

[c] By 2-sample Student *t* test.

[d] No. of days was calculated after completion of telemedicine or discharge from the hospital.

lems, patient and clinician acceptance, reimbursement from third-party payers, and legal challenges [10]. Technical problems, such as video freeze-ups and spontaneous termination of connections caused by the low bandwidths of plain old telephone service, remain for many programs because of the lack of available broadband service in some areas. (In Hawaii, however, 80% of homes have cable service [Time Warner Oceanic Cable] through which broadband service is available for telemedicine communication.) Although catastrophic earthquakes, as occurred in 2010 in Haiti and Chile, could disrupt telephone and cable lines, crippling snowstorms, such as the ones in the United States and Europe during the winter of 2009–2010 that shut down transportation services to and from hospitals and clinics, should not interfere with telehealth visits between providers and patients.

Although patients treated by telemedicine have had satisfactory clinical outcomes, more rapid convalescence, and increased comfort at home, some patients have reported feeling safer in a hospital environment than at home. Care providers may be unwilling to bear the entire burden of caring for a patient; it may be necessary to provide respite workers to shop, cook, and clean and to provide companionship for some patients.

In general, clinicians remain skeptical about whether the evidence is sufficient to change the current practice of not discharging febrile patients before clinical improvement is achieved. This reaction may be based on traditional teachings and clinicians' fear of unsuccessful outcomes and, in turn, the potential threat of litigation. Telemedicine may increase the work load of physicians. Appropriate compensation will be a prerequisite to physician buy-in. Some believe that use of telecommunications technology threatens basic components of medical care. One author warned "against excessive reliance on technology to the detriment of traditional clinician-patient relationships and against complacency regarding the risks and responsibilities—many of which are as yet unknown—that distant medical intervention, consultation, and diagnosis carry" [25, p 615]. The author emphasized that an intangible aspect of traditional health care is threatened, specifically "the comfort and compassion human beings can only bring each other when they are face to face" [25].

Despite a large number of success stories attesting to the cost-effectiveness of telemedicine in the home, not all commercial third-party insurers reimburse for home televisits. More positive outcome-based data from randomized comparison studies are needed to confirm the efficacy and cost savings of home telemedicine.

Medical-legal challenges for poor outcomes related to telemedicine in the home may occur, as did during the early days of OPAT >3 decades ago. With time and satisfactory outcomes data, however, OPAT became a standard of care, and fear of litigation dissipated.

CONCLUSION

Telemedicine in the home has several advantages over hospitalization. It promotes more efficient use of hospital beds, resulting in cost savings, and patients tend to convalesce more rapidly at home. This latter phenomenon may be related to several factors, including removal of the patient from a passive-dependent posture in the hospital to more active participation in his or her own medical care at home. The active involvement of patients in their own care results in a sense of empowerment over their illness.

Although the clinical use of telemedicine in the United States is still limited, in the future, there may be increased numbers of health care providers seeing patients at remote sites on a desktop or laptop computer. Clinicians will select interactive video and store-and-forward modes as needed and seamless access to pertinent patient records, radiographs, pathology slides, pharmacy information, and billing records. They will have at hand the content of online libraries of medical information, diagnosis and treatment algorithms, and patient instructional materials. Referral to specialists and allied health personnel will be made by computer-based scheduling. Patient information will be stored in archives accessed by authorized medical personnel anywhere in the world.

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As both a means of communication and a new diagnostic and therapeutic modality, telemedicine should be approached with scientific skepticism and caution. Research into its safety, efficacy, cost-effectiveness, and patient and clinician satisfaction must be a high priority. Telemedicine may still be medicine at a distance, but its range of applications has changed it from a technological augmentation of medical care to a novel system of health care. This integration of information technology with the health care system is a process that will redefine future medical care.

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