How Often Is Medication Taken as Prescribed?

A Novel Assessment Technique

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The evaluation of the efficacy of medication is confounded when patients do not adhere to prescribed regimens. Overdosing, underdosing, and erratic dosing intervals can diminish drug action or cause adverse effects. Using a new method with epilepsy as a model, we assessed compliance with long-term medications among newly treated and long-term patients. Medication Event Monitor Systems (Aprex Corporation, Fremont, Calif) are standard pill bottles with microprocessors in the cap to record every bottle opening as a presumptive dose. Compliance rates averaged 76% during 3428 days observed: 87% of the once daily, 81% of the twice daily, 77% of the three times a day, and 39% of the four times a day dosages were taken as prescribed. Coefficients of variation of drug serum concentrations had no significant relationship to compliance rates. Pill counts overestimated compliance increasingly as compliance with the prescribed regimen declined. Neither drug serum concentrations nor pill counts would have identified the frequency of missed doses that were revealed with continuous dose observations.

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MEDICAL practitioners in all fields have long known that patients do not routinely follow instructions for the use of medication or other aspects of treatment. Prior reviews have estimated the extent of patient default at 20% to 82%.[1] The disparity between the highest and lowest estimates can be attributed to methodology, leaving us with few data from which to extrapolate rates of noncompliance, even for specific populations. Nevertheless, converging evidence from all disciplines indicates that poor compliance or adherence to prescribed dosage is pervasive.[1]

The social and medical expense of an uncontrolled disease makes it worthwhile to look carefully at pill-taking habits before pursuing costly tests or adding more medication. The inability of a patient to adhere to dosing instructions could explain many apparent drug failures. The issue of noncompliance is also of major importance in clinical trials where stratification of dose, level, and duration of use are methods to compare drugs.

Although medical staff usually believe that the use of medication as prescribed is important to treat specific problems, patients are often ambivalent, forgetful, or careless or deny their illness. These characteristics occur in all populations, no matter how severe the illness or how much education about the disease process is attempted.[2] Treatment outcomes of numerous acute and chronic diseases, ranging from otitis media to diabetes, are affected by nonadherence to the prescribed regimen. Epilepsy is an example of a disorder that, once diagnosed, requires lifelong medical attention, making it an ideal model for a study of compliance. Unlike insidious hypertension or hyperlipidemia that may not be evidenced with a stroke or infarct for many years, patients have experienced at least two seizures before the diagnosis of epilepsy is established. The need for drug therapy is part of the discussion of the diagnosis, and patients are educated about the importance of taking medication regularly and ways to avoid precipitating seizures. Seizures can occur at any time, without warning. The social, psychological, and medical consequences of continued seizures are severe, suggesting the highest motivation to adhere to treatment. An unexpected seizure can lead to embarrassment, costly medical reevaluation, loss of a driver's license, or loss of a job. Nevertheless, patients with epilepsy are usually otherwise normal people whose attitude toward medication is as varied as that of the general population.

Until now, measurement of compliance has relied on several methods. No single one is entirely satisfactory and no "gold standard" exists. The most obvious means of documentation is history, despite the potential for inaccuracy. Positive information is helpful, but false negatives are common. The patient and family can and should be asked if doses are taken as prescribed. The availability of drug serum concentration testing has provided a useful measure of medication intake but does not explain failure of efficacy or adverse effects between tests. Drug serum concentrations are most useful for compounds with long half-lives because results provide an approximation of use during the preceding week or longer. For rapidly cleared drugs, brief intake before the blood test can provide results that show adequate drug serum concentration, erroneously suggesting regular medication use. Monitoring the methods used in research protocols, such as counting the number of leftover pills or days between prescription refills, also has drawbacks. Pill counts can be confound-

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ed if unused bottles are mislaid or deliberately not returned. Taking occasional extra pills can balance with days of missed pills to provide an erroneous impression of adherence.[3] No information is available to indicate whether medication is taken daily or at the hourly interval prescribed.

A need has existed for a method that could measure adherence to a treatment regimen on a daily and hourly basis and that would be minimally intrusive to the ambulatory outpatient. Continuous dosage monitoring, like continuous ambulatory electrocardiographic monitoring, would provide objective, long-term information about patient routines. Such a tool has been developed recently in the form of a special medication bottle that records the time of each bottle opening. We used this novel method to study compliance with prescribed regimens and compared the results with other, traditional measures.

PATIENTS AND METHODS

Medication Event Monitoring Systems ([MEMS] Aprex Corporation, Fremont, Calif) were used to observe the pill-taking habits of individual patients. The MEMS bottles were standard 30-dram pill bottles fitted with a cap that contained a microprocessor. Each bottle opening and closing was recorded as a presumptive dose. Data were retrieved by connecting the bottle to a microcomputer communication port. Each battery-operated cap collected up to 350 events between visits for data retrieval. When the cap memory was full, earliest events were replaced by recent openings. Collected data were sent to the Aprex Corporation by diskette for analysis using proprietary software. Information was provided as listings of the date and time of individual bottle openings and closings, the duration of opening, and the hours since the previous dose. Calendar plots show the number of doses taken each day and the mean and SD of weekly and overall compliance for individual patients (Fig 1). Also provided were the ranges of dose intervals and the times doses were taken.

Patients who were taking one or two antiepileptic drugs were invited to participate in a study of how people take prescribed medication. The plan was to assess daily time and frequency patterns of dosage and seizure occurrence. Patients were informed of the recording device in the bottle cap and consented to participate. They were asked to fill the bottles once a week, to remove only one dose at a time, and to use only the MEMS bottle to dispense their pills. No change was made in the drug dose, the number of doses, or the times doses were taken. Dosage patterns included once daily dosage (QD), twice daily dosage (BID), three times a day dosage (TID), or four times a day dosage (QID), as prescribed by the physician. The definition of noncompliance or nonadherence was omission of a scheduled dose. For the purposes of this study, taking double pills to make up for a missed dose, taking an extra dose the next day, or skipping doses altogether was considered noncompliance. The monitoring day began at 3:01 AM and ended at 3 AM to cover early-morning and late-night dosing.

Mon	Tue	Wed	Thu	Fri	Sat	Sun
			4	2	3	3
5	4	4	4	5	1	4
4	4	3	1	3	3	2
4	3	2	4			

No. of Doses	1	2	3	4	5
No. of Days	2	3	6	9	2

QID = 38%

Fig 1.—Top, Calendar plot shows the number of doses taken daily by a patient who was prescribed four times-a-day (QID) dosing. Bottom, The summary lists the frequency of dosing patterns for the whole observation period.

Patients

Patients were grouped by prescribed dosage regimen (1, 2, 3, or 4 doses daily) and by the severity and type of epilepsy.

Group A.—Six newly treated patients with adult-onset seizures who had recently been diagnosed as having partial epilepsy after experiencing several complex partial and/or secondarily generalized tonic clonic seizures constituted group A. They were participating in a double-blind study that used an active drug and a placebo that matched the alternate drug (carbamazepine or valproate), both taken BID. Patients in group A were educated about the diagnosis of epilepsy, life-style adaptations, and the need for long-term, regular use of medication.[4] In addition to the physician, a research assistant helped them with medical and psychosocial problems, provided medication, and arranged for close follow-up.

Group B.—The second group included 12 adult clinic patients who were in long-term treatment and had long-standing, poorly controlled partial epilepsy. These patients had been given various drugs over the years in attempts to find the most effective and least toxic combination or sole treatment (using carbamazepine, phenytoin sodium, and primidone). Patients in group B were well known to the clinic staff and had been assisted with their seizure-related problems for many years. General support about medication dose and standard reinforcement with reports of the ranges of drug serum concentrations were familiar to these patients, without specific counseling. Regimens included three QD, three BID, five TID, and one QID.

Group C.—Six patients in group C had long-standing, childhood-onset, generalized epilepsy that included recent tonic clonic seizures, often accompanied by absence and myoclonic seizures. Although similar to group B in their experience with long-term medication, these patients were participating in an open study to crossover from a multiple-drug regimen that did not control seizures to an alternative, single drug (valproate) used to maximal tolerable dose and taken TID (n = 3) or QID (n = 3). Patients in group C received support and extensive education similar to group A, with additional education about the potential for breakthrough seizures during the complex drug-crossover period. Patients in groups A and C were provided with detailed written and verbal explanations about the diagnosis and rationale for their treatment program.

Neuropsychological Tests

Neuropsychological tests were administered to assess intelligence (estimated full-scale IQ based on four subtests from the Wechsler Adult Intelligence Scale–Revised), immediate and delayed recall of verbal and pictorial information (Wechsler Memory Scale, Russell adaptation), and aspects of personality (using subscales from the Minnesota Multiphasic Personality Inventory, including depression [Scale 2], anxiety [Scale 7], and psychopathic deviance [Scale 4]).

Drug Serum Concentrations

Drug serum concentrations were tested at each visit, usually at 1- to 2-month intervals, with frequency varying depending on clinical requirements. Fluoroimmunoassays (TDx, Abbott Laboratories, North Chicago, Ill) were used for analyses. The therapeutic ranges were as follows: carbamazepine and primidone, 17 to 55 μmol/L; phenytoin, 40 to 80 μmol/L; and valproate, 485 to 1000 μmol/L.

Table 1.—Compliance Rates for Prescribed Dosing Regimens

Dosage*	No. of Patients	Mean No. of Days Observed	Mean (SD) Compliance Rate, %†	Range, %
QD	3	191	87‡ (11)	73-99
BID	12	161	81§ (17)	44-100
TID	7	102	77§ (12)	52-90
QID	4	52	39 (24)	3-68
All	26	132	76 (21)	3-100

*QD indicates once daily; BID, twice daily; TID, three times a day; and QID, four times a day.
†$P<.01$ by analysis of variance.
‡$P<.01$ vs QD group by Student's t test with Bonferroni multiple comparison correction.
§$P<.05$ vs QD group by Student's t test with Bonferroni multiple comparison correction.

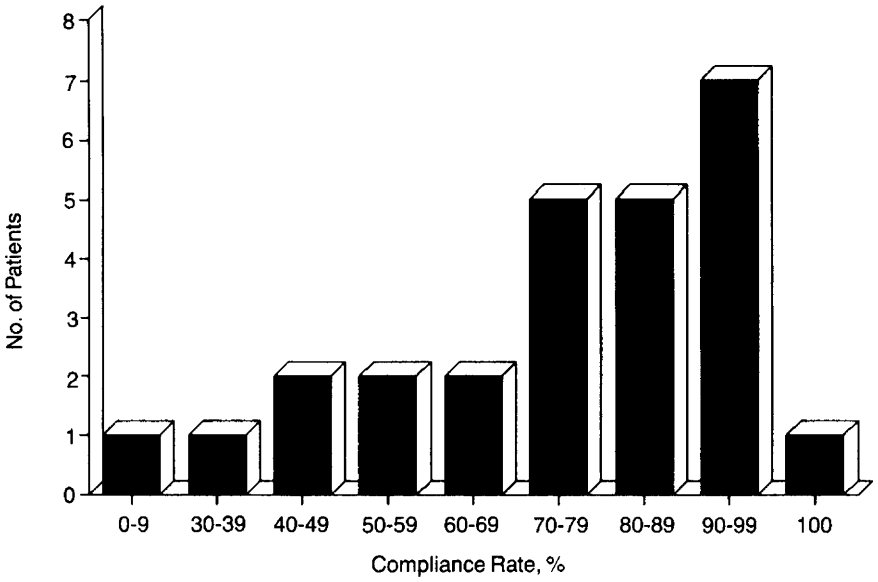

Fig 2.—Distribution of compliance rates for drug regimens.

Table 2.—Compliance Rates by Treatment

	Treatment		
	A New	B Long-term	C Crossover
Mean, %*	76	81	55
SD, %	22	13	29
Range, %	44-100	52-99	3-84
No. of patients	6	12	6
Mean No. of days observed	130	94	65

*$P<.05$ by analysis of variance.

Statistical Evaluations

Statistical evaluations were performed by analysis of variance with Student's t tests between groups and Bonferroni multiple comparison corrections. Data are presented as mean ± SD, except where SE is defined. The compliance rate was calculated as follows:

(Number of Days During Which Doses Were Taken as Prescribed/Number of Days Observed) × 100%

Pill count was calculated as follows:

(Total Number of Doses Observed/Number of Doses Prescribed × Number of Days Observed) × 100%

Coefficients of variation (CVs) among drug serum concentrations were assessed for patients who had three or more drug serum concentration tests during MEMS monitoring as follows: CV = SD/mean × 100. Regression analyses of compliance rates with CVs and with pill counts were performed using a commercially available statistical software package (SYSTAT Inc, Evanston, Ill). Multiple regression was used for neuropsychological analyses.

RESULTS

MEMS Monitoring

Twenty-four patients who took 7413 doses during 3428 days were observed. Twelve men and 12 women, aged 18 to 68 years, volunteered to use MEMS bottles. Eleven patients took one antiepileptic drug from MEMS bottles and 13 patients took two drugs. Two of the double-drug patients had different regimens for each drug (BID and TID) so final data show 26 regimens for 24 patients (3 QD, 12 BID, 7 TID, and 4 QID). Observation ranged from 2 to 37 weeks, with a mean of 14 weeks and a median of 13 weeks.

Dose Schedule.—Table 1 lists the mean percent of days during which patients took the prescribed number of doses, expressed as a compliance rate. The decline in rate (QD, 87%; BID, 81%; TID, 77%; and QID, 39%) showed poorest adherence to the QID regimen ($P<.05$ vs QD and $P<.01$ vs BID and TID). Figure 2 shows the range of compliance rates among the population. Zero doses were taken on occasional days (average, 10%) by 9 patients, averaging 2.6% of days, but 1 patient missed 20% of all QD doses, and 1 patient missed 23% of all BID doses. A single dose was taken on occasional days by 18 of 21 patients who were scheduled for multiple daily doses (BID, TID, or QID).

Patient Groups.—As shown in Table 2, compliance rates among newly treated patients in group A averaged 76% (range, 44% to 100%), increasing among long-term patients who have epilepsy in group B to 81% (range, 52% to 99%), and declining among patients in the crossover protocol in group C to 55% (range, 3% to 84%) ($P<.05$, analysis of variance).

Overall.—Observation of 9.4 patient-years included the notation of 5599 doses taken as prescribed out of 7413 doses observed and 2600 days during which patients took all doses as prescribed out of 3428 days observed (mean, 14 weeks). Thus, whether using a compliance rate based on individual patients or drugs and days or doses observed, the overall data converged to show that approximately 76% of doses were taken by patients with epilepsy as prescribed.

Pill Count

The MEMS reports were also used as a measure of the overall quantity of pills taken during observation, which is comparable to a pill count. The patients' average pill count for the 36 medications was 92% (QD, 99%; BID, 92%; TID, 91%; and QID, 90%). The range of 59% to 108% indicated that patients took more doses on some days and fewer doses on other days. A positive correlation was found between pill counts and compliance rates ($r = .697$, $P<.001$) (Fig 3). The intercept (69% ± 8.6% [2 SEs]) indicated a significantly higher pill-count index as compliance declined, demonstrating overestimation of compliance by pill count.

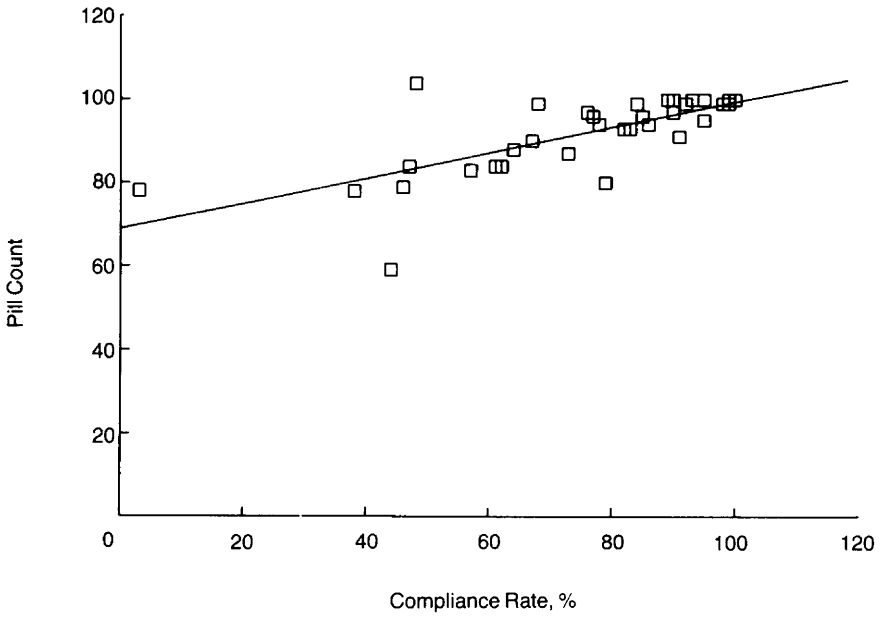

Fig 3.—Regression analysis of compliance rates and pill counts (compliance = [0.69 + 0.31] × pill count, $P<.001$).

Drug Serum Concentration

Therapeutic Range.—A total of 140 drug assays were performed (mean, 5 per drug per patient), 117 of which were within the therapeutic range. Twelve drug serum concentrations were low, but 7 represented a steady state for two individuals because of dose-limiting side effects, and 1 occurred during a dose change. Four drug serum concentrations from four patients were unexpectedly low, but within 10% of the therapeutic lower limit. All 7 drug serum concentrations above the therapeutic range were attributable to dose increases in two patients and fluctuation around the upper end (72 to 83 μmol/L) of the therapeutic range for phenytoin in one patient. Thus, 97% of 140 tests were within the therapeutic range or attributable to a physician's plans at the time of the test.

Variability.—Coefficients of variation in the concentrations of 23 drugs averaged 19% ± 8% (range, 7% to 34%). No significant differences were found (analysis of variance) among the following drug group or dosage group CVs: carbamazepine, 20% ± 7%; phenytoin, 23% ± 7%; valproate, 17% ± 9%; QD, 14% ± 4%, BID, 21% ± 7%; TID, 23% ± 8%; and QID, 12% ± 7%. Linear regression of compliance rates and CVs provided no suggestion of correlation between the two measures ($r=.07$, $P=.6$). Pill counts and CVs were also unrevealing ($r=.26$, $P=.2$).

Neither use of the therapeutic range for individual drug serum concentrations nor variation in concentrations contributed information about compliance during long-term observation. The MEMS continuous monitoring included periods between tests, making it a more sensitive tool.

Case Reports of Seizures

The MEMS reports provided evidence of seizure-related noncompliance not evident by history, drug serum concentrations measured at the clinic, or total pill counts. Seven patients reported seizures during monitoring, five of whom had at least 1 seizure (totaling 12 of 16 seizures) associated with missed doses documented by MEMS reports. An additional 2 seizures were linked to lack of sleep when MEMS reports listed late-night bedtime dosing and early-morning dosing. These patients had a type of epilepsy that could be precipitated by sleep deprivation.

Patient 1 reported a tonic clonic seizure on a Sunday morning after having missed sleep and skipped both his Saturday doses and Sunday morning dose before the seizure. He did not recall skipping doses, and his valproate level was in the midtherapeutic range when tested 5 weeks later.

Patient 2 reported seven complex partial seizures, four of which occurred after he missed all three doses the day prior. Two additional seizures occurred after he missed the evening dose for 2 days prior (one seizure) and also the afternoon dose (one seizure). The omission of one or two doses from the TID schedule for 2 days likely resulted in lowered carbamazepine and phenytoin serum concentrations that allowed seizure breakthrough. This patient was able to document having had a seizure but not having missed doses on previous days.

Patient 3 reported a complex partial seizure although he did not recall skipping the morning dose of both carbamazepine and phenytoin (18-hour dose interval).

Patient 4 had three tonic clonic seizures, two of which occurred after omission of a dose noted by monitoring. Both times the 16- to 18-hour lapse between doses allowed significant decline in valproate levels. A detailed review of her bedtime and breakfast dose times during the week of her third seizure showed frequent nights of sleeping from 4 AM to 10 AM. This cycle might have contributed to the seizure that occurred without missed doses. Knowledge that noncompliance had precipitated the event avoided a medication change for that patient. Rather than add another drug immediately, the physician used MEMS data that described the dosing that preceded the event, and then decided to maintain the same medication plan with additional compliance counseling for this patient. Although drug levels were within the therapeutic range, they varied among visits, providing additional evidence of erratic medication habits.

Patient 5 reported a tonic clonic seizure that was not correlated with missed doses, although her dosage pattern was erratic and showed overcompliance throughout the monitoring period. She often took an extra midmorning valproate dose and clustered the four doses during the day, leaving a lengthy overnight hiatus. These data confirmed the failure of monotherapy to provide adequate seizure control.

Patient 6 had a complex partial seizure after 2 days of omitted morning doses from her BID schedule of carbamazepine and phenytoin.

Patient 7 experienced a tonic clonic seizure attributed to sleep deprivation.

Another patient was observed to omit medication on 20% of days, although not before days of scheduled examinations, when phenytoin levels typically were in the therapeutic range. He was witnessed having a seizure before MEMS monitoring and was brought to the hospital for immediate testing that showed subtherapeutic drug serum concentrations.

Demographic and Neuropsychological Data

Complete data for demographic and neuropsychological variables were

available for 13 of 24 patients. Estimated full-scale IQ scores ranged from 76 (borderline) to 124 (superior), with a mean of 99 (average range). Immediate verbal memory on the Wechsler Memory Scale ranged from 9 (severely impaired) to 33 (high normal), with a mean of 19 (mildly impaired); and delayed verbal memory declined to a range of 3 (severely impaired) to 31 (high normal), with a mean of 15 (mildly impaired). Minnesota Multiphasic Personality Inventory subscale T scores ranged from 40 to 102. Clinically significant (>70 Minnesota Multiphasic Personality Inventory T scores) levels of depression, anxiety, and nonconformity were found in 7, 3, and 3 patients, respectively. These profiles were typical of increased depression seen in the epilepsy population.

Preliminary data analyses determined that some demographic-neuropsychological variables showed high intercorrelations. Specifically, patients with memory impairment generally showed deficits on immediate and delayed recall trials of both verbal and nonverbal memory measures. Similarly, subjects with one elevated Minnesota Multiphasic Personality Inventory subscale score tended to show high scores on other subscales. To avoid problems of multicollinearity among independent variables, only the measures that showed the strongest correlation with compliance rate (delayed verbal memory and Minnesota Multiphasic Personality Inventory anxiety subscale) were entered into the final regression analysis. Preliminary analysis also showed that several demographic variables (education and full-scale IQ) showed very low correlations with the dependent variable. These items were dropped from subsequent analyses.

In the final multiple regression analysis, the combined effects of delayed verbal memory, anxiety, and age accounted for the greatest proportion of variance (0.402) in the dependent variable compliance. However, this finding was not significant ($F[3,9]=2.01$; $P<.18$), given the variability among measures in this small sample of subjects. The small group did not provide adequate power to exclude differences among groups.

COMMENT

Despite the potential for socially unacceptable and medically dangerous consequences, we found that patients with epilepsy took only an average of 76% of their medication as prescribed when carefully monitored. The traditional methods for compliance assessment have been patient interviews, drug serum concentration or other biological marker, and pill count, none of which can be considered a gold standard. Each method measures a different aspect of compliance. The MEMS reports add a fourth dimension by explaining the total number of doses, the number of doses taken daily, and whether the prescribed schedule was used. In addition, detailed review of dose time, as well as dose frequency, can be used to understand drug serum concentrations and link events such as seizures to specific dosage patterns.

Samples that show erratic or absent drug concentrations have been a valuable aid in suggesting noncompliance.[5] However, use of single drug serum concentrations to estimate compliance is subject to numerous flaws, including assumed half-life and individual clearance rates; time of last dose and absorption characteristics; and dose adjustments for side effects or tolerance and low efficacy. Finding a drug serum concentration within the therapeutic range or small variation in repeated levels cannot be assumed to reflect good compliance. Continuous dose observations bridged the gap between occasional therapeutic drug monitoring and potential novel drug delivery systems that could provide medication independent of patient action.

Pill counts neither indicated which days the patients took the appropriate, more, or fewer pills than were prescribed, nor could investigators be certain that pills were not discarded before counting to enhance the appearance of having complied with the regimen.[6] Our data demonstrated that although patients used an average of 92% of pills by count, they did not take these pills according to instructions based on pharmacokinetic or pharmacodynamic rationales designed for their safety. The unreliability of pill counts because of discarded pills has been anecdotal among researchers, although the lack of methods to test the technique has hindered analysis. Pullar et al[7] demonstrated its flaws in a study of pill counts of a hypoglycemic drug and level-dose ratios of tiny doses of phenobarbital used as a marker. Pill counts failed to identify 87% of patients who were low compliers as documented by tracer levels. The observed trend in Fig 3 showed close correlation when rates were high for both measures, but the compliance rate was more sensitive than the pill count. For example, a patient who took daily morning doses but forgot evening doses half the time would have a pill count of 75%, although the BID regimen was maintained on only 50% of days. Unfortunately, the same pill count can be derived by a patient who forgets all doses on 25% of days, or skips many doses and takes extra pills occasionally.

Early attempts to use automated devices to record doses were not feasible because appropriate technology was not available.[8,9] The currently available MEMS units are a convenient, unobtrusive system for observing daily pill-taking habits. The MEMS bottles counted each opening as a presumptive dose, with no assurance that the patient had taken the appropriate number of pills or any pills at all from the bottle at that time. However, review of daily dosage patterns of bottle openings at regular intervals, day after day, made it unlikely that volunteer patients would have taken the time to open the bottle at set intervals but not consume their medication.

The specific, timed MEMS record of medication intake not only provided evidence of individual dosing patterns, but also allowed correlation with clinical events. It would be useful to have MEMS bottles available as a laboratory test. A 1-month assessment would provide the physician with a detailed report to understand better why treatment has not been fully successful. The availability of monitoring information could improve patient safety by preventing unnecessary dose increases or drug changes.

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ambiguity. As noted in the article, models that include other variables (including main effects) were not shown because they did not improve or alter the model of Table 1. This was true for the duration of methadone treatment as well. That Hispanics were similar to whites in some ways and similar to blacks in others obviously is not a methodological flaw but rather a simple fact.

We describe both the study population and the target population in the "Methods" section. Rather than making "unjustified population generalizations," our data serve to underscore the importance of subpopulations of IV drug users, eg, cocaine users, at significantly higher risk of HIV infection. The existence of IV cocaine users who do not use heroin supports an important conclusion in our article: that increased treatment of heroin addiction will not by itself solve the problem of HIV infection in IV drug users.

We believe it is clear that IV cocaine use is associated with HIV infection in the population that we studied, and other researchers have found similar associations in other populations.[1,2] It would be unfortunate if public health policymakers refused to accept this fact because of trumped up methodological quibbles.

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Learning Theories and Medical Lectures: Add Little to Little and There Will Be a Big Pile

To the Editor.—I was disappointed by the commentary in *JAMA* entitled "Learning Theories Implicit in Medical School Lectures."[1] After pointing out correctly that medical school faculty rarely are trained as educators and that their lecture styles derive from personal experiences, Dr Cook goes on to name and describe four styles. He gives us two similes and two naive psychological styles and implies that medical school lecturers view learning as a passive process, while he waits for help from "educational researchers" and the evolution of new styles.

Learning by medical students is of overriding importance to our society, and this commentary is a smoke screen hiding the real issues. With all the troubles that beset the various aspects of medicine today, and in the past, the spectacular advances in the art, science, and provision of medical care cannot be denied. The vigor and productiveness of the discipline always has depended on successfully attracting bright, motivated people who are able to find and secure the knowledge they need in a polyglot system of laboratories, clinical exposure, lectures, and libraries.

The real issue is not the style of medical school lectures but the falling popularity of our profession and the diminished quality of those who enter it. With fewer than two applicants for every position, and those with greatest potential diverted to other careers, better teaching can have the most limited value.

The real issue is making medicine attractive to those who will continue the excellence that has been demonstrated in the past.

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1. Cook RI. Learning theories implicit in medical school lectures. *JAMA*. 1989;261:2244-2245.

To the Editor.—I thoroughly enjoyed reading the commentary by Dr Cook.[1] As a medical student, I have found at least one instructor representative of each theory. However, one type of lecturer, whom I have encountered on numerous occasions, was not described. This is the practitioner of the exhumation theory.

Practitioners of this method believe that all medical students have an unlimited amount of time, energy, and interest; that this is the only course worthy of a lifetime pursuit; and, of course, that medical school is the student's entire life. Lecturers assume that students will have the passion to dig down into, and eagerly wade through, multiple layers of minutiae to unearth, on their own, a few deeply buried pearls of wisdom. These pearls often appear so small and insignificant that they are readily overlooked. The first problem with this method is the failure of the instructor to realize that students are always taking more than a single course; if several lecturers in different courses all subscribe to the exhumation theory, the results are total chaos, mass confusion, and a feeling of futility, which in turn cause reduced attention span and decreased productivity.

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1. Cook RI. Learning theories implicit in medical school lectures. *JAMA*. 1989;261:2244-2245.

In Reply.—I appreciate the comments of Dr Wallach and Ms Dyer. I do not agree that present medical students are inferior to their predecessors. Those of my acquaintance are enthusiastic, bright, and dedicated to the difficult task of becoming a physician. I agree with Dr Wallach that learning by medical students is of overriding importance. Lectures are a major part of the educational curriculum and, unlike other factors, the style of lecture presentation remains completely under faculty control. The exercise of this control reflects on the medical school faculty and not on the students.

Ms Dyer describes yet another style of lecture presentation, although this may be a variation on the diffusionist theme. She also has identified a major issue in curriculum planning: the cumulative effect of lecture style. Otherwise minor characteristics of lecture style can have untoward results when lecture frequency is high. This problem is acknowledged by medical educators[1] but probably is best summed up by the Roman poet Ovid: *adde parvum parvo magnus acervus erit* (add little to little and there will be a big pile).

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CORRECTIONS

Incorrect Wording.—An error occurred in the Medical News & Perspectives article entitled "Maternal, Child Health Needs Noted by Two Major National Study Groups," published in the March 24/31 issue of THE JOURNAL (1989;261:1687-1688). On page 1688, the first sentence in the third complete paragraph in column 1 should have read as follows: "The reports offer specific suggestions, such as expanding Medicaid to cover all pregnant women whose family income is below 185% to 200% of the poverty line [not '185% to 200% below the poverty line']. . . ."

Incorrect Table Footnotes.—An error occurred in an Original Contribution entitled "How Often Is Medication Taken as Prescribed? A Novel Assessment Technique," published in the June 9 issue of THE JOURNAL (1989;261:3273-3277). On page 3275, the last two footnotes in Table 1 should have read as follows: "‡$P<.01$ vs QID [not 'QD'] by Student's t test with multiple Bonferroni comparison correction. §$P<.05$ vs QID [not 'QD'] by Student's t test with multiple Bonferroni comparison correction."