Cost and cost-effectiveness of standard methadone maintenance treatment compared to enriched 180-day methadone detoxification

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ABSTRACT

Aims To compare the cost and cost-effectiveness of methadone maintenance treatment and 180-day methadone detoxification enriched with psychosocial services.

Design Randomized controlled study conducted from May 1995 to April 1999.

Setting Research clinic in an established drug treatment program.

Participants One hundred and seventy-nine adults with diagnosed opioid dependence.

Intervention Patients were randomized to methadone maintenance ($n = 91$), which required monthly 1 hour/week of psychosocial therapy during the first 6 months or 180-day detoxification ($n = 88$), which required 3 hours/week of psychosocial therapy and 14 education sessions during the first 6 months.

Measurements Total health-care costs and self-reported injection drug use. A two-state Markov model was used to estimate quality-adjusted years of survival.

Findings Methadone maintenance produced significantly greater reductions in illicit opioid use than 180-day detoxification during the last 6 months of treatment. Total health-care costs were greater for maintenance than detoxification treatment ($7564 versus $6687; $P < 0.001$). Although study costs were significantly higher for methadone maintenance than detoxification patients ($4739 versus $2855, $P < 0.001$), detoxification patients incurred significantly higher costs for substance abuse and mental health care received outside the study. Methadone maintenance may provide a modest survival advantage compared with detoxification. The cost per life-year gained is $16 967. Sensitivity analysis revealed a cost-effectiveness ratio of less than $20 000 per quality-adjusted life-year over a wide range of modeling assumptions.

Conclusions Compared with enriched detoxification services, methadone maintenance is more effective than enriched detoxification services with a cost-effectiveness ratio within the range of many accepted medical interventions and may provide a survival advantage. Results provide additional support for the use of sustained methadone therapy as opposed to detoxification for treating opioid addiction.

KEYWORDS Cost-effectiveness, health care, injection drug use, methadone detoxification, methadone maintenance, opiate use.

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INTRODUCTION

Concerns about the rising costs of health care have increased interest in economic evaluation of drug abuse treatment. Methadone is an effective treatment for opioid dependence (National Consensus Development Panel on Effective Medical Treatment of Opiate Addiction 1998) but varies in effectiveness and cost (Mann & Feit 1982; Sorensen *et al*. 1982; Gerstein *et al*. 1994; Harwood *et al*. 1995; Barnett 1999). To date, the literature has focused more on effectiveness than the cost-effectiveness of this pharmacotherapy. There is limited but increasing evidence of its cost-effectiveness (Bradley *et al*. 1994; Kraft *et al*. 1997; Barnett 1999; Doran *et al*. 2003). As responsibility for funding methadone shifts to the public sector, and as treatment expansion is constrained by resource limits, there is a greater need to assess the economic consequences and cost-effectiveness of methadone treatments (McCarty *et al*. 1999). Such assessment can help policy makers decide how to allocate resources for substance abuse treatment.

The effectiveness of methadone is enhanced by the inclusion of ancillary services in programs, such as counseling, social services and medical care (McLellan *et al*. 1993). Kraft *et al*. (1997) found that counseling and support services that were intermediate in intensity were more cost-effective than minimum or high levels. However, questions remain about how variations in the type and intensity of support services affect methadone treatment outcomes, and the cost-effectiveness of providing such services.

Methadone detoxification yields worse outcomes than methadone maintenance treatment, but some have suggested that if it is supplemented with intensive psychosocial services, it may be preferable to sustained methadone maintenance (Reilly *et al*. 1995). Others have raised questions about whether enhancing methadone detoxification treatment with contingency management is cost-effective. In a randomized trial comparing 180 days of methadone detoxification to detoxification enhanced with contingency contracting, adding contingency contracting caused modest improvement in outcomes (Hartz *et al*. 1999).

In a more recent study, standard methadone maintenance was found more effective than 180 days of methadone detoxification with enriched services (Sees *et al*. 2000). Once individuals had completed their 180 days of detoxification, they had poorer retention in treatment, greater heroin use, more risky injection practices and more legal problems than individuals in standard methadone maintenance treatment. This paper examines data from this study to examine the cost-effectiveness of methadone maintenance relative to 180 days of enriched detoxification.

METHODS

Experimental design and sample

Opioid-dependent drug abusers who met eligibility criteria and gave informed consent were assigned randomly to sustained methadone maintenance treatment (MMT, $n = 91$) or 180-day methadone detoxification enriched with intensive psychosocial services followed by drug-free substance abuse treatment (M180, $n = 88$). There were no significant differences between groups at baseline.

Interventions

For both treatment conditions, the maximum methadone dose was 100 mg/day.

MMT participants were eligible for 14 months of methadone maintenance, followed by a 2-month detoxification. The 14-month period was intended to provide 12 months of follow-up uncontaminated by patients' anticipation of subsequent detoxification. MMT participants were required to attend 1 hour per week of group therapy for the first 6 months and 1 hour per month of individual psychotherapy throughout the study.

M180 participants were eligible for 14 months of substance abuse treatment. During the first 6 months of treatment, 120 days of induction or maintenance were followed by 60 days of dosage reduction. Participants were required to attend for 2 hours per week of substance abuse group therapy, a series of 14 weekly 1-hour substance abuse education classes and weekly individual therapy sessions.

Outcome measure

Outcomes data have been reported previously (Sees *et al*. 2000). Self-reported data on heroin use from the Addiction Severity Index (ASI) was gathered at study entry and monthly thereafter (McLellan *et al*. 1992). Although urine toxicology screening was performed throughout this study, the use of self-report data allowed us to measure reductions in illicit opioid use, not abstinence only.

Methadone treatment costs

Methadone treatment costs were estimated using the 'microcosting' method recommended by the US task force on cost-effectiveness analysis (Luce *et al*. 1996). We estimated the unit costs of admission services, individual and group counseling, education classes, ongoing medical care, methadone dispensing and urine collection. We surveyed how staff used their time to provide services during three different months. Labor costs including wages, benefits and employer taxes were determined from accounting records.

Supply costs included the cost of methadone doses and urinalysis. The cost of clinic space was the rental cost of comparable medical office space. Indirect costs included clinic space, utilities, medical and office supplies and the labor costs of activities that were not attributable to a specific service. These were distributed to each service in proportion to its share of direct cost. Unit costs were determined by dividing the total cost of a service by the units of service provided in the survey months.

Health care utilization and cost

Information on hospital stays, emergency room visits and ambulatory medical care was obtained from the public health system administrative database. Charges were adjusted by the ratio of cost to charges.

Substance abuse and mental health treatment was obtained from appropriate administrative databases. Costs were estimated as the county contract rate.

Study participants were asked monthly about medical, substance abuse and mental health treatment that they received. We estimated the cost of this care as mean cost for the same service in the county health system. The cost of in-patient stays was assumed to be proportional to length of stay. We excluded self-reported care already represented in administrative data.

Statistical methods

Total cost incurred by treatment group was compared using the Mann–Whitney Wilcoxon test, a non-parametric analog to the *t*-test (Marascuilo & Serlin 1988). This test was also used to compare groups during the first and second 6 months of the study, and to compare cost and utilization subtotals. Group comparisons of monthly self-reported heroin use were conducted using a random effects regression model (Liang & Zeger 1986). Independent variables included treatment group, indicator of baseline assessment, indicator of an assessment in the last 6 months of the study and interactions between this indicator and treatment group. As observations were clustered by participant, the model included a participant-level error term to avoid any bias to the standard errors.

Participants failed to complete 15% of the monthly surveys. More data were missing from M180 participants (19.1%) than MMT participants (9.3%). We ignored missing data points, and thus assumed that a missing self-report of health-care utilization meant that no costs were incurred outside the county health system and that self-reports of heroin use were missing at random. The long-term model of cost-effectiveness ignored the 30 participants unavailable for the second 6 months of the study. We imputed missing values in a sensitivity analysis.

Model of cost-effectiveness

Cost-effectiveness analysis considers the life-time cost and benefit of a health-care intervention. Because the main clinical trial was just 12 months long, we used data from the last 6 months of the study as the best source of information on long-term differences between groups. We evaluated the incremental cost-effectiveness of methadone maintenance relative to 180-day-long detoxification. A cost-effectiveness ratio was calculated, the difference in quality-adjusted life-years divided by the difference in cost. This method, recommended by the Federal panel on cost-effectiveness on health care (Gold *et al.* 1996), and applied widely to health care, allows our result to be compared to ratios of other studies. Methods of making quality adjustments have not yet been developed for substance use disorders (Barnett & Hui 2000). Hence, we used life-years of survival as our outcome measure, and then conducted sensitivity analysis to consider the consequence of quality adjustment on our results.

A different method, cost–benefit analysis, has been used to determine whether substance abuse treatment is a good use of public funds (Gerstein *et al.* 1994; Harwood *et al.* 1995). This method finds a benefit-to-cost ratio, which is the difference in dollar value of outcomes divided by the difference in cost. We elected not to use this method. As it is rarely used to evaluate health interventions, there is no standard for how high the cost–benefits ratio must be to regard a treatment as cost-effective. In addition, ways of assigning monetary values to human life are controversial.

We used the long-range perspective of the health-care system, requiring us to include capital and fixed costs. We estimated the provider's cost of replicating the intervention. Staff cost included both time spent dispensing methadone and conducting general clinic operations, and was estimated for a period when staff was fully engaged in providing services. Facility costs were included, but protocol development and research costs were not. Cost-adjusted charges were used to estimate the cost of health-care services; and because it is frequently the basis of provider reimbursement, it also represents the perspective of the payer. Costs incurred by patients for transportation and the value of the time lost traveling to treatment were not included.

We considered both years of survival and quality of life. To estimate the effect of changes in drug use, we used mortality estimates from other studies. Annual mortality rates of treatment dropouts range from 1.58% to 6.91%; they range from 0.56% to 1.50% for those in methadone treatment (Barnett 1999). The annual mortality rate for patients with minimum drug treatment ranged from 3.03% to 8.25%. We included the two deaths observed during the study in the analysis. We made quality of life adjustments based on observed days of methadone use and reported days of heroin use.

For participants who survived beyond the end of the trial, we projected future survival and health-care costs using a Markov model. The model was constructed using cost and outcome data on individual participants, and incorporated the variance and covariance of costs and outcomes observed during the trial. The model used an annual cycle and two health states, 'alive' and 'dead'. The probability of surviving to the next cycle depended on age at the start of the cycle, the frequency of heroin use and the number of years since the start of the model. Age-specific mortality was added to an additional risk that was proportional to the rate of heroin use. Mean heroin use reported by that participant during the second 6 months of the trial was included in the model. In our model, differences in heroin use and costs observed among trial participants diminished in a linear fashion over a 10-year period; and we used the mean costs and heroin use among all participants to project beyond 10 years.

To adjust for quality of life, we applied participants' costs and heroin use data to cycles in which the participant was alive, and derived costs and outcomes by summing over 100 Markov cycles. The half-cycle correction was used to correct for the difference between the discrete nature of the model and the continuous nature of the survival process (Sonnenberg & Beck 1993). We conducted sensitivity analyses to test our analytical assumptions.

Confidence intervals for cost-effectiveness results were determined using the bootstrap method (O'Brien *et al.* 1994). We sampled with replacement from the study data, including modeled life-time cost and outcomes. Each sample had 149 observations, the number of trial participants. We sampled 1000 replicates and calculated the percentage that did not meet the criteria for cost-effectiveness. This fraction represents the probability of a Type 1 statistical error. We calculated the *P*-statistic for cost-effectiveness using different criteria for cost-effectiveness, to calculate an acceptability curve for the intervention (van Hout *et al.* 1994).

RESULTS

Health service utilization

The MMT group was retained for an average of 310.7 days, compared to an average of 139.2 days for the 180 day detoxification group ($P < 0.001$). Most participants randomized to MMT (70.3%) completed the full year of planned treatment, compared to 33.0% of participants randomized to detoxification who completed at least 175 of the 180 days of planned treatment.

Table 1 compares the treatment groups' utilization of medical, substance abuse and mental health services.

Table 1 Mean quantity of health services utilized by randomization group.

	Treatment group	
Type of service	*M180-day (n = 88)*	*MMT (n = 91)*
In-study methadone dosing visits	128.93	272.33***
Out-of-study methadone dosing visits	29.44	5.73***
Total methadone dosing visits	158.38	278.06***
In-study substance abuse group visits	40.40	19.84***
In-study individual psychotherapy visits	13.56	15.55
Out-of-study detoxification visits	3.53	1.52**
Out-of-study medication-free detox. visits	3.58	1.57
Mental health visits	2.47	1.52
Residential substance abuse treatment stays	0.09	0.01*
Residential substance abuse treatment days	4.11	0.07
In-patient hospital admissions	0.23	0.31
Days of hospital stay	0.84	0.86
Emergency medical care visits	0.73	0.93
Out-patient medical care visits	2.55	3.75*

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.

The MMT group had significantly more methadone visits in the experimental setting than the M180 group ($P < 0.001$). The M180 group attended significantly more methadone dosing visits outside the study ($P < 0.001$) than the MMT group. The MMT group had 75.6% more methadone visits over the entire study ($P < 0.001$).

The M180 group had more group counseling visits in the experimental setting ($P < 0.001$), detoxification visits outside the study ($P < 0.01$) and residential substance abuse treatment stays than the MMT group ($P < 0.05$). However, there were no significant differences between the groups in total days of residential treatment or in other types of substance abuse or mental health treatment obtained. The MMT group had significantly more out-patient medical care visits ($P < 0.05$), but there were no differences between groups in their use of acute hospital or emergency room care.

Treatment cost

The cost of methadone was estimated to be $7.35 per dispensed dose plus 0.0082 per mg of methadone dispensed. Unit cost of services provided within study were: admission intake and physical $324.59 per admission, ongoing medical care $26.80 per week, individual counseling sessions $0.41 per minute, education sessions $6.83 per session, cocaine group sessions $11.78 per session, relapse group $14.01 per session and urinalyses, $14.56 per test.

Table 2 Mean health care cost by randomization group.

Type of service	Treatment group M180-day (n = 88)	MMT (n = 91)
Substance abuse care provided by study	2855.28	4738.50***
Other speciality substance abuse and mental health treatment	1404.41	454.86***
Subtotal, speciality substance abuse and mental health treatment	4259.70	5193.36***
In-patient hospitalization	1874.65	1656.58
Emergency care	161.98	235.38
Out-patient medical care	400.44	478.88*
Subtotal, medical care	2437.07	2370.84
Total, all services	6696.77	7564.20***

*$P < 0.05$; ***$P < 0.001$.

Table 3 Mean days of heroin use in prior 30 days by randomization group.

Assessment	Treatment group M180-day (n = 88)	MMT (n = 91)
Baseline	29.42	29.70
Month 1–6	7.17[a]	6.91[a]
Month 7–12	13.95[a,b]	6.70[a,c]

[a]Significantly less than baseline; $P < 0.001$. [b]Significantly more than months 1–6; $P < 0.001$. [c]Significantly less than M180-day detoxification for months 7–12; $P < 0.001$.

Table 2 compares substance abuse, mental health and medical care costs of the two treatment groups. The MMT group incurred higher substance abuse treatment costs in the experimental setting ($P < 0.001$) and higher total cost for substance abuse and speciality mental health care ($P < 0.00$). The M180 group incurred significantly higher costs from substance abuse and mental health care received outside the study ($P < 0.001$). There were no significant differences in medical care costs, except that the MMT group incurred significantly more out-patient medical care costs ($P < 0.05$). Overall, the MMT group incurred 13% more total health-care costs than the detoxification group ($P < 0.001$). During the last 6 months of the trial period, the MMT group incurred $3311 in health-care costs; the M180 group incurred $2919 ($P < 0.001$).

Outcome

Participants' heroin use is reported in Table 3. At the study baseline, participants reported almost daily heroin use. During the first 6 months of the study, both groups reported a statistically significant decline to an average of 7 days per month ($P < 0.001$), with no significant difference between groups. During the final 6 months of the study there was no significant change in heroin use in the MMT group, but heroin use in the M180 group increased significantly to 13.9 days per month ($P < 0.001$), slightly more than twice the number of days than the standard methadone group ($P < 0.001$).

Model of cost-effectiveness

We describe our base case model and then our sensitivity analyses. The base case analysis assumes an additional 0.1% risk for each day of heroin use in the previous month. This is consistent with mortality rates from the literature. Participants reported 4.8 days of heroin use in months that they received at least 25 methadone doses. Thus, we assigned them a 0.48% excess annual mortality rate. When added to the 0.25% mortality rate of a 40-year-old American this is a total mortality rate of 0.73%, consistent with the rate for methadone-maintained patients in observational studies. Participants reported 16.1 days of heroin use in months in which they received five or fewer methadone doses. A 1.61% excess mortality rate was assigned; the 1.86% total mortality is consistent with rates observed in methadone dropouts. Individuals who used heroin 30 days per month were assigned a 3.0% excess mortality rate; 3.25% total mortality is at the lower end of the range of rates reported for untreated heroin-dependent individuals.

Our base case model assumed that the effects of the intervention would be dissipated after 10 years, when participants would have 1% excess mortality and a $7084 annual health-care cost. This was the mean cost incurred by study participants and the mortality risk associated with the mean reported level of heroin use. We assumed a linear trend from participants' own costs and excess mortality risk to that of the study mean.

Using these assumptions, participants randomized to MMT were expected to survive 31.0 years and incur $218 thousand dollars in life-time health-care costs. Participants in the M180 group were expected to survive 30.4 years and incur $209 thousand dollars in life-time health-care costs. The incremental cost-effectiveness of MMT compared to 180-day detoxification was $14 497 per life-year (LY) gained. Discounting costs and benefits using the standard 3% rate yielded a cost-effectiveness ratio of $16 967 for MMT. This ratio indicates that MMT is cost-effective compared to M180 treatment, if we apply the US health-care system standard of adopting treatments that cost less than $50 000 per quality-adjusted life-year (Owens 1998).

The model estimated that the MMT group had greater life-time costs and longer survival. Therefore, we compared the two groups on these outcomes and found that discounted cost was significantly greater for the MMT group ($P < 0.001$), as was the raw cost ($P < 0.05$). Similarly, discounted survival was significantly greater in the MMT group ($P < 0.05$), but the raw number of quality-adjusted years of survival was not significantly greater ($P = 0.13$). The bootstrap analysis found that in 71% of the replicates MMT had an incremental cost-effectiveness ratio of less than $50 000 per LY. This translates to a 0.29 probability of a Type 1 statistical error. We calculated the acceptability curve for the cost-effectiveness of MMT. The probability that the ratio was statistically significant varies from $P = 0.84$ with criteria of strong dominance to $P = 0.19$ against an acceptance threshold of $1 000 000/LY. At no point in this range was the *P*-value less than 0.05. The cost-effectiveness ratio that we report is stated in terms of life-years of survival; we discuss the possible effect of quality adjustment of survival below.

Sensitivity analyses

We evaluated whether our results were sensitive to our modeling assumptions (Table 4). We changed the 3% discount rate used in the baseline model to 5% discount rate. The incremental cost-effectiveness ratio increased slightly, to $18 542 per life-year.

We changed the assumption that group differences would be eliminated after 10 years. With a 5-year time horizon, the incremental cost-effectiveness ratio was $22 057 per life-year, with a 20-year time horizon it was $15 710.

We changed our assumptions about the effect of heroin use on mortality. When we assumed great mortality, an excess risk of 0.15% for each day per month of heroin use, the incremental cost-effectiveness ratio was $12 809. This assumption is consistent with 0.72% excess mortality among those in treatment, 2.4% excess mortality among those who had detoxified and 4.5% among daily users.

With an assumption of lower risk, the incremental cost-effectiveness ratio was $24 889. This was based on the assumption that a history of heroin use added 0.2% to annual mortality, and that there was an additional risk of 0.07% per day/month current heroin use. This is consistent with a 0.54% excess mortality among those in treatment, 1.3% excess mortality among those who had detoxified from methadone and 2.3% excess mortality among those who use heroin daily; rates are lower than any of the mortality rates reported in the literature.

We considered how heroin use and methadone treatment might affect quality of life. Cost-effectiveness analysts adjust years of survival using utility, a measure that allows quality of life to be equated with quantity of life. The utility scale spans from a value of 0, representing death, to 1, representing perfect health.

Table 4 Cost-effectiveness results and sensitivity analyses.

Case considered	*Cost-effectiveness ratio*
Base case analysis	$16 967/LY
10-year time horizon	
3% discount rate	
Excess mortality of 0.1% per day/month heroin use	
No quality of life adjustment	
5% discount rate	$18 542/LY
5-year time horizon	$22 057/LY
20-year time horizon	$15 710/LY
High level of mortality (0.15% per day/month heroin use)	$12 809/LY
Low level of mortality (+ 0.2% risk for history of heroin use and 0.07% per day/month heroin use)	$24 889/LY
Large effect of heroin on quality of life (deduct 0.02 utilities per day/month heroin use)	$6 271/QALY
Very large effect of heroin and methadone on quality of life (deduct 0.03 utilities per day/month heroin use, 0.01 per methadone dose/month)	$19 997/QALY
Base case with missing outcomes and cost data imputed	$17 671/LY

We assumed first that heroin use has a large impact on quality of life, and that methadone maintenance treatment has no effect. This model deducted 0.02 utilities for each day per month of heroin use. Thus, an individual who uses heroin on 5 days of each month would have a quality of life that was 0.10 utilities less than perfect health (i.e. $0.02 \times 5 = 0.10$). Because the definition of perfect health is 1.0 utilities, this is 0.90 utilities. Individuals who used heroin on 16 days per month would be regarded as having 0.32 fewer utilities than perfect health ($0.02 \times 16 = 0.32$), or 0.68. Individuals who returned to daily heroin use, that is, 30 days use per month, would have 0.60 fewer utilities ($0.02 \times 30 = 0.60$) or 0.40 utilities. These assumptions about quality of life yielded a cost-effectiveness ratio of $6271 per quality adjusted life year (QALY).

Next we assumed that both methadone and heroin severely reduce quality of life; a reduction of 0.03 utilities for each day/month of heroin use and 0.01 for day/month of methadone treatment. These represent 59% of normal quality of life for the average patient in treatment, 52% of normal for the average patient outside treatment and 10% for the patient who uses heroin daily. The incremental cost-effectiveness ratio was $19 997.

These findings suggest that the intervention was cost-effective under a broad range of assumptions about quality of life. The cost-effectiveness ratio was less than $20 000/QALY as long as it was assumed that the quality of life of the typical methadone patient (with 5 days/month of heroin use and 26 days of methadone use) was at least 10% greater than the typical patient who had detoxified from methadone (with 16 days/month of heroin use).

Holding the difference in quality of life between heroin use and methadone treatment constant, the incremental cost-effectiveness ratio was larger (the intervention is regarded as less cost-effective) when heroin use and methadone treatment were assumed to have especially negative effects on quality of life. The intuition of this result is that the cost-effectiveness ratio increases as the value of the years of life saved by the intervention declines. More specifically, when opioid dependence is regarded as a greater loss in the quality of life, the extra years of life gained from treatment are multiplied by a smaller quality adjustment. The quality-adjusted years of life in the denominator is smaller and the cost-effectiveness ratio is greater (treatment is regarded as less cost-effective).

Imputation of missing values

Our baseline model assumed that data were missing completely at random. We considered an alternate assumption: that missing values are randomly different from the non-missing values of similar participants. We imputed missing values by selecting from the non-missing observations of participants with similar characteristics using the approximate Bayesian bootstrap (Rubin & Schenker 1991). Imputation for successive months used a sequence of logistic regressions, as described by Lavori *et al.* 1995). The dependent variable was a missed follow-up visit. The independent variables included baseline values for ASI, depression and risk behaviors, as well as the previous month's responses for heroin use and non-county health and treatment cost. The logistic probability score was used to rate observations according to their propensity to be missing. Missing values were imputed by selecting at random with replacement from non-missing observations in the same propensity score quintile. This process was repeated until all 12 months' data were complete. Missing data were imputed in 10 replicates.

With missing data imputed, we applied the other assumptions of the base case, including discounting costs and benefits at the standard 3% rate. This yielded a cost-effectiveness ratio of $17 671 for MMT.

We conducted statistical significance testing of the sensitivity analyses. None of the cost-effectiveness results were statistically significant when compared to a critical threshold of $50 000 per QALY. Two of the sensitivity analyses were marginally significant ($P < 0.10$) when compared to critical cost-effectiveness ratios of $100 000/QALY or higher. These were the analyses that assumed the intervention had a 20-year time horizon or a high risk of mortality from heroin use (0.15% per day/month of use).

DISCUSSION

We found that standard methadone maintenance is a cost-effective treatment relative to 180-day-long methadone detoxification. The direct cost of methadone treatment and total health-care costs were greater for the methadone maintenance group. However, methadone maintenance treatment was more effective in reducing illicit opioid use than 180-day detoxification; in the final 6 months of the study, detoxification patients had 2.08 times more use than was reported by patients receiving standard methadone treatment. Although the 180-day detoxification group received more psychosocial services than the standard methadone group, it had poorer drug treatment outcomes.

Our base case model yielded a cost-effectiveness ratio of $16 967 per life-year gained for standard methadone, which is within the range of accepted medical interventions (Drummond *et al.* 1993; Mason *et al.* 1993; Freedberg *et al.* 1998; Pinkerton *et al.* 1998) and well within the $50 000 threshold that some analysts use to judge cost-effectiveness (Owens 1998). Sensitivity analyses in which several assumptions about life expectancy and quality of life were considered, yielded cost-effectiveness ratios of less than $20 000 per QALY. Findings from the present study indicate that methadone maintenance treatment can be a cost-effective option for the treatment of opioid dependence.

There is growing evidence demonstrating that methadone treatment is a cost-effective intervention (Barnett 1999; Zaric *et al*. 2000). In a study of the effect of methadone treatment on mortality, the authors found that providing access to methadone had an incremental cost-effectiveness ratio of $5915 per life-year gained (Barnett 1999). Other work considered not only mortality, but also quality of life and transmission of HIV and the effect of methadone treatment on medical care costs (Zaric *et al*. 2000), and found that expansion of methadone treatment had a cost-effectiveness ratio of between $8200 and $10 000 per QALY, depending on the prevalence of HIV in the community. Most of the benefit in averted HIV infections and reduced morbidity and mortality would be realized by the general population. Together, these findings demonstrate that methadone maintenance treatment is a cost-effective intervention and that the cost-effectiveness ratio compares favorably with other health-care interventions.

We acknowledge the limitations of our study. We did not include social outcomes such as employment, criminal activity or social service use for two reasons. First, such outcomes are not ordinarily considered in economic evaluation of health-care interventions; by including them, our cost-effectiveness ratio would not be comparable to the cost-effectiveness ratios observed for other health-care interventions. Secondly, the decision to include these outcomes depends on the perspective of the analysis. Other studies have found that an important social consequence of reduced opioid use is the reduction in property loss due to crime (Gerstein *et al*. 1994; Harwood *et al*. 1995). Analyses have included this consequence by adopting the perspective of the 'law-abiding citizen'. Our decision to exclude social costs is conservative, underestimating the potential societal benefit of methadone maintenance treatment.

Interview data were missing for some patients. We assumed that these patients incurred no health-care costs outside the public treatment system and that self-reports of heroin use were missing at random. When we imputed missing data, the cost-effectiveness result was essentially unchanged.

We did not consider the indirect cost of treatment borne by the patient, such as transportation costs and the value of the time lost traveling to treatment, effects of treatment on long-term illicit drug use and health and the effects of aging on health-care costs. However, there is considerable controversy as to whether cost-effectiveness analysis should include the cost of treating unrelated diseases that occur in the added years of life (Garber *et al*. 1996). Future cost-effectiveness studies with larger samples should be undertaken to explore the effects of methadone treatment duration on long-term illicit drug use and health outcomes.

Our findings indicate that standard methadone treatment provides greater health benefits and is more cost-effective than 180-day detoxification enriched with psychosocial services. Continuation of treatment beyond an initial 6 months of care appears to be a cost-effective way to reduce morbidity and mortality caused by opioid addiction. Additional cost-effectiveness studies are needed to evaluate methadone in other settings and alternative pharmacotherapies such as buprenorphine. Cost-effectiveness research can help to inform decisions about funding, coverage and reimbursement, so treatment may be provided in a way that achieves the greatest benefit to society.

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