

# Estimating the Number of HIV-Infected Injection Drug Users in Bangkok: A Capture-Recapture Method

## ABSTRACT

**Objectives.** The purpose of the study was to estimate the number of injection drug users infected with the human immunodeficiency virus (HIV) in Bangkok to allow planning for health services for this population.

**Methods.** A two-sample capture-recapture method was used. The first capture listed all persons on methadone treatment for opiate addiction from April 17 through May 17, 1991, at 18 facilities in Bangkok. The second capture involved urine testing of persons held at 72 Bangkok police stations from June 3 through September 30, 1991. Persons whose urine tests were positive for opiate metabolites or methadone were included on the second list.

**Results.** The first capture comprised 4064 persons and the recapture 1540 persons. There were 171 persons included on both lists, yielding an estimate of 36 600 opiate users in Bangkok. Existing data indicate that 89% of opiate users in Bangkok inject drugs and that about one third are infected with HIV, yielding an estimate of approximately 12 000 HIV-infected injection drug users in Bangkok in 1991.

**Conclusions.** During the 1990s the number of cases of acquired immunodeficiency syndrome (AIDS) and other HIV-related diseases, including tuberculosis, in the population of HIV-infected injection drug users in Bangkok will increase dramatically, placing new demands on existing health care facilities. The capture-recapture method may be useful in estimating difficult-to-count populations, including injection drug users. (*Am J Public Health*. 1994;84:1094-1099)

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## Introduction

The explosive initial phase of the epidemic of human immunodeficiency virus type 1 (HIV-1) infection in Thailand occurred in 1988 among injection drug users in Bangkok, the capital, presumably as a result of transmission via the sharing of injection equipment.<sup>1,2</sup> The rate of HIV-1 seropositivity among opiate users seeking drug treatment in this city of 6 million people rose from 0% to 1% in late 1987 to 32% to 43% in late 1988.<sup>2</sup> From 1989 through 1993, seroprevalence among persons in opiate treatment programs stabilized at approximately 35% to 40%.<sup>2</sup> Existing data indicate that heroin is the principal drug used by 97% of persons seeking drug treatment in Bangkok and that 89% of such persons inject the drug.<sup>3</sup> Since 1988 the HIV-1 epidemic in Thailand has extended to persons with other risk behaviors for HIV infection; rates of HIV-1 seropositivity have increased dramatically among female prostitutes, young men seeking treatment at sexually transmitted disease clinics, and 21-year-old male military conscripts.<sup>2,4</sup>

An accurate estimate of the total number of injection drug users in Bangkok could be used to estimate the number of HIV-infected injection drug users. This estimate would be helpful in assessing the amount of HIV transmission that is due to injection drug use as compared with transmission due to sexual activity. Such an estimate could also be used to plan drug treatment programs and other health services for this population. In particular, an estimate of the number of HIV-infected injection drug users would allow for a reasonable prediction of the number of acquired immunodeficiency syndrome

(AIDS) cases to expect among this population in the coming decade. The care of injection drug users with AIDS and HIV-related infections such as tuberculosis will likely place a great burden on existing health care facilities in Bangkok and elsewhere in Thailand.

We employed a capture-recapture method to estimate the number of opiate users in Bangkok and then used existing data to estimate the total number of injection drug users and the number of HIV-infected injection drug users in this city in 1991.

## Background

Opiate use in Thailand dates back more than 300 years. Although there were

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This paper was accepted December 28, 1993.

**Note.** The use of trade names is for identification only and does not imply endorsement by the Public Health Service or by the US Department of Health and Human Services.

**Editor's Note.** See related annotation by Neugebauer and Wittes (p 1068) in this issue.

laws in the 18th century prohibiting the use of opium, the trade in and use of opium were regulated until 1959, when opium use was banned.<sup>5</sup> In 1959, opium smokers were required to register, resulting in the documentation of 70 985 users, about half of whom were in Bangkok.<sup>5</sup> Heroin use was not noted until shortly after 1959, and the practice of injecting heroin, predominantly by young men, increased in the second half of the 1960s.<sup>5</sup> Opium poppies have traditionally been grown in the mountainous Golden Triangle region that includes northern Thailand, Myanmar (Burma), and Laos. This region is one of the world's foremost heroin-producing areas. The street price (200–500 baht [US\$8–20] per gram) of 60% to 90% pure ("No. 4 grade") heroin in Bangkok, 700 km to the south, is among the lowest in the world. Compared with the official daily minimum wage of 100 baht (US\$4) in Bangkok, the relative cost of regular heroin use is considerably lower in Thailand than in other countries where illicit heroin use is a problem. A recent study in Bangkok indicated that 69% of 600 injection drug users had some form of legitimate employment, but also that 69% had spent time in prison since they began injecting heroin.<sup>1</sup>

Free treatment services for drug users in Bangkok are provided by the Bangkok Metropolitan Administration and the Ministry of Public Health. Law enforcement control is waived for clients.<sup>6</sup> The Bangkok Metropolitan Administration operates 17 outpatient drug treatment clinics throughout the city and the Ministry of Public Health operates Thanyarak Hospital, a 500-bed inpatient facility with an active outpatient department, in Pathum Thani on the northern edge of Bangkok. Methadone treatment, usually lasting 45 days, is the principal mode of opiate detoxification. Routine urine screening for opiates indicates that a large proportion (40%–80%) of persons receiving outpatient methadone treatment continue to use heroin while in treatment (Bangkok Metropolitan Administration, unpublished data). Admissions to treatment are reported to the Drug Dependence Information System, operated by the Office of the Narcotics Control Board of the Office of the Prime Minister and the Department of Medical Services, Ministry of Public Health, in collaboration with the Institute of Health Research, Chulalongkorn University.<sup>6</sup> In 1989, this system recorded 28 457 courses of drug treatment in Bangkok; 95% of the clients were men, 87% were aged 20 through 39 years, and 82% were outpa-

tients.<sup>3</sup> Multiple treatments for the same person were recorded as separate events.

The total number of injection drug users in Bangkok is not reliably known; however, efforts have been made to estimate the number of persons served by the 17 Bangkok Metropolitan Administration treatment facilities. For the years 1986 through 1989, the number of treatment admissions ranged from 22 522 to 24 355. When duplicate names were eliminated from admission records, the number of persons treated annually ranged from 7238 to 8591, indicating an average of three treatment courses annually per patient served.<sup>7,8</sup> These data were used in a multiple-recapture analysis (using admission data from the three trimesters of a year as separate captures) to estimate the drug treatment population. In this analysis, the treatment population in the years 1986 through 1989 was estimated to be between 16 460 and 21 655 persons.<sup>7,8</sup> However, this method was thought to underestimate the total opiate-using population in Bangkok because it did not adequately account for persons not receiving treatment.

In 1989, the Bangkok Metropolitan Administration conducted a modified key informant study<sup>9</sup> of persons receiving methadone treatment to determine the proportion of heroin users in treatment. Clients were asked to list the persons they knew who used heroin and to indicate whether these persons had ever been admitted to a treatment program. The mean number of persons listed on 1944 questionnaires was 5.3 (SD = 3.2). The proportion of heroin users who had ever been in treatment was 0.626.<sup>10</sup> Dividing the estimated annual treatment population (16 460 to 21 655) by this proportion yields an estimate of 26 294 to 34 593 total heroin users. However, because this method assumes that all heroin users are known by drug users in treatment, it may underestimate the actual heroin-using population.

## Methods

The study protocol was approved by the Ethical Review of Research Committee of the Thai Ministry of Public Health. A two-sample capture-recapture method was used.<sup>11,12</sup> The first capture was of all persons who were enrolled in methadone treatment programs for opiate addiction during the period April 17 through May 17, 1991, at the 17 clinics and at Thanyarak Hospital. For Thanyarak Hospital, only Bangkok residents and only those on

outpatient treatment or those discharged from inpatient treatment were included. A confidential list was compiled containing forename and surname, gender, age, date of birth, Thai national identification number, and date of last methadone treatment.

The recapture was conducted from June 3 through September 30, 1991. Study teams made 891 visits on 66 days to 72 police stations in all areas of Bangkok. Included in the survey were persons held at police stations who had been arrested within the previous 72 hours. Urine samples were collected and the following information was recorded confidentially: forename and surname, gender, age, date of birth, Thai national identification number, and reason for arrest. Urine was tested by enzyme immunoassay for the presence of opiate metabolites (Emit d.a.u. Opiate Assay, Syva Co, Palo Alto, Calif) and methadone (Emit d.a.u. Methadone Assay, Syva Co, Palo Alto, Calif). The cutoff for positive, 300 ng/mL, was recommended by the manufacturer and was described as being 100% predictive of the presence of these substances. Information on persons with urine tests positive for opiate metabolites or methadone was included on a list for further analysis.

Information collected in the lists from the two captures was entered twice into a computer database in the Thai language. After keypunch errors were corrected, duplicate entries were removed from each list by means of a combination of computer sorting and visual inspection. The two lists were then merged, computer sorted by multiple variables, and visually inspected to identify the same entries (matches) in both lists. Criteria used to determine matching entries are shown in Table 1. Names were considered similar if they contained only minor spelling differences that did not change the name. This definition was established in view of the complexity of the Thai alphabet, which consists of 44 consonants, 32 simple and compound vowels (some written as super- or subscripts or combinations), and 4 tone markers. Dates of birth were considered similar if they varied by no more than one digit.

An estimate of the total population of opiate users ( $n$ ) was made with the formula:

$$\text{Estimate of } n = \hat{n} = \frac{c_1 c_2}{m},$$

where  $c_1$  and  $c_2$  are the numbers of persons in the first and second capture,

**TABLE 1—Criteria Used to Determine Matching Persons in the Two Captures and Number of Matches Identified for Each Match Type**

Match Type	No. of Matches	Forename	Surname	Age	Date of Birth	Thai ID Number
A	9	Same	Same	Same	Same	Same
B	65	Same	Same	Same	Same	...
C	52	Same	Same	Same	Similar	...
D	45	Similar/same	Similar/same	Same	Similar/same	...
E	4	Different	Similar/same	Same	Similar	...
F	15	Similar/same	Similar/same	Different	Different	...

Note. Gender was the same for all match types.

**TABLE 2—Reasons for Arrest for Persons Included in the Second (Police Arrest) Capture (n = 1540)**

Reason for Arrest	No.	%
Marijuana-related	833	54.1
Heroin-related	421	27.3
Gambling	99	6.4
Robbery	73	4.7
Inhalant use	49	3.2
Assault	10	0.6
Other	55	3.6

respectively, and  $m$  is the number of persons identified in both captures (matches).<sup>13</sup> The following formulas were used to calculate the variance (Var) and 95% confidence interval (CI) for the estimate of  $n$ :

$$\text{Var}(\hat{n}) = \frac{c_1 c_2 (c_1 - m)(c_2 - m)}{m^3}$$

$$95\% \text{ CI} = \hat{n} \pm 1.96 \sqrt{\text{Var}(\hat{n})}$$

These formulas<sup>13</sup> were also used to determine age-stratum-specific estimates of  $n$ . Stratum-specific estimates of  $n$  and variances were then summed to determine the total  $n$  and 95% confidence interval.

Population rates were calculated using 6 million as the total Bangkok population and 1 244 000 (20.7%) as the number of 20- through 39-year-old male Bangkok residents.<sup>14</sup>

## Results

In the first capture, 4064 persons remained on the list after 478 duplicate names were removed. The mean age was 32.5 years (SD = 7.7); 34.0% were aged 20 through 29 years; 52.0% were aged 30 through 39 years; and 93.6% were male.

Name and gender were recorded for all persons; also recorded were age for 99.7%, date of birth for 88.3%, and national identification number for 79.9%.

In the recapture, 8212 persons were surveyed at police stations. Included on the list (following the removal of 105 duplicate names) were the 1540 (18.8%) persons whose urine tests were positive for opiate metabolites (1513 [98.2%]) or methadone (198 [12.9%]); 171 (11.1%) were positive on both assays. The mean age of those with positive urine tests was 29.8 years (SD = 7.0); 45.4% were aged 20 through 29 years; 41.8% were aged 30 through 39 years; and 94.3% were male. Name and gender were recorded for all persons; also recorded were age for 99.9%, date of birth for 94.3%, and national identification number for only 2.8%. The reasons for arrest are shown in Table 2. Reportedly, persons possessing heroin were commonly charged with marijuana possession to expedite processing at police stations.

Match types A through D (Table 1) were considered to be true matches. By this standard, comparisons of the two lists identified 171 matches, yielding an estimate of 36 600 (95% CI = 31 538, 41 662) opiate users in Bangkok in 1991 (Table 3). Since the age distributions in the two captures were different ( $P < .01$ ), a stratified analysis by age groups was conducted, yielding an estimate of 36 376 (95% CI = 30 996, 41 757) opiate users.

Various criteria were used to estimate  $n$  (Table 4). Using more restrictive (more specific) matching criteria by excluding type D matches increases the estimate of  $n$  by 35.7%, to 49 671. Conversely, using less restrictive (more sensitive) criteria by including type E and F matches decreases the estimate of  $n$  by 10.0%, to 32 940.

An estimate of 32 574 injection drug users (5 per 1000 persons in the total

Bangkok population) results from the use of existing data indicating that 89% of opiate users seeking drug treatment in Bangkok inject the drugs.<sup>3</sup> However, since 94% of injection drug users are men and 87% are aged 20 through 39 years, the rate of injection drug users among men aged 20 through 39 years is 21 per 1000. Data from drug treatment programs indicate that roughly one third of all opiate users were HIV-1 seropositive in 1991<sup>2</sup>; it is likely that all were injection drug users, resulting in an estimate of approximately 12 000 injection drug users infected with HIV-1 (2 per 1000 total population). The rate of HIV-infected injection drug users among men aged 20 through 39 years is 8 per 1000.

## Discussion

In 1991, it was estimated that there were 300 000 HIV-infected persons in Thailand.<sup>2</sup> Epidemiologic evidence suggested that the majority of these infections resulted from heterosexual transmission<sup>2</sup>; however, limited data were available to estimate the number of HIV-infected injection drug users. Capture-recapture methodology can be used to estimate the size of difficult-to-count subpopulations, although the reliable use of this method is not easily achieved.<sup>15,16</sup> It was possible to use this method in Bangkok, in part, owing to the availability of drug treatment and the great variety of Thai names.

Interest in enumerating injection drug user and prostitute populations, because of their increased risk for HIV transmission, recently led the World Health Organization's Global Programme on AIDS to review capture-recapture methods.<sup>17</sup> These methods have been used extensively in biologic sciences to enumerate animal populations<sup>18,19</sup> and have been used in the United States to evaluate the completeness of national reporting systems for congenital rubella syndrome<sup>20</sup> and mortality due to tetanus<sup>21</sup> and pertussis.<sup>22</sup> The numbers of drug users in Amsterdam,<sup>23</sup> in two boroughs of London,<sup>24</sup> and in Rome<sup>25</sup> have been estimated by a two-capture method. More recently, a multiple-recapture method was used to estimate the numbers of injection drug users<sup>26-28</sup> and female street prostitutes<sup>29</sup> in Glasgow, Scotland. Four major assumptions must be satisfied for the two-capture method to produce reliable results.<sup>11,12,30</sup>

The first assumption is that the population is closed. In reality, no city is closed and this assumption can only be

satisfied to a reasonable degree. If the population of opiate users is very dynamic, with members entering and leaving with great frequency, the recapture will be less likely to include persons identified in the first capture, resulting in a falsely low number of matches and an overestimate of the population of opiate users. To allow for the assumption that the opiate user population was reasonably stable during the study period, we limited the duration of the study to less than 6 months. Although we could not determine the number of opiate users who entered or left the city, it is unlikely that a substantial proportion did so during this brief period.

The second assumption is that the capture sources are independent. There is no clear positive or negative dependence between receiving methadone treatment and, at a later time, being arrested. The two captures were conducted sequentially with a 2-week period between them to allow for persons receiving methadone treatment in April or May to be at risk for arrest in June through September. The urine testing employed in the recapture permitted the detection of persons from the first capture who had either continued methadone or stopped methadone while using opiates. It could be argued that persons receiving methadone treatment have a decreased need for heroin (and therefore money) and are therefore less likely to be involved in criminal activity that would lead to arrest (negative dependence). However, in the second (police arrest) capture, we identified 198 persons with urine tests positive for methadone, 171 (86.4%) of whom were also positive for opiate metabolites. Conversely, one could argue that persons who receive methadone treatment are more likely to be arrested because of their increased likelihood of being identified as drug users by the police (positive dependence); however, we found no evidence that this occurred. The assumption of independence among captures is not required if more than two captures are employed; log-linear modeling is used to account for dependence among the captures.<sup>13</sup> In Bangkok, we were unable to identify a practical source for a third capture.

The third assumption is that all members of the population have the same probability of being captured. Free methadone treatment is available to all opiate users in Bangkok. All opiate users have a probability of seeking drug treatment and therefore of having been identified in the first capture; however, it is likely that

**TABLE 3—Estimates of the Number of Opiate Users in Bangkok (n), by Unstratified and Age-Stratified Analyses**

Age Group	Capture 1	Capture 2	No. of Matches	n	95% Confidence Interval
<b>Unstratified analysis</b>					
All	4064	1540	171	36 600	31 538, 41 662
<b>Stratified analysis</b>					
< 20 y	76	78	4	1482	105, 2859
20–29 y	1378	699	76	12 674	10 059, 15 289
30–39 y	2106	644	80	16 953	13 543, 20 363
> 39 y	491	118	11	5267	2336, 8198
All	4051	1539	171	36 376	30 996, 41 757

**TABLE 4—Estimates of the Number of Opiate Users in Bangkok (n) Based on the Number of Matches Identified<sup>a</sup>**

Match Types	No. of Matches	n	95% Confidence Interval
A–B	74	84 575	65 946, 103 205
A–C	126	49 671	41 490, 57 852
A–D	171	36 600	31 538, 41 662
A–E	175	35 763	30 883, 40 643
A–F	190	32 940	28 658, 37 221

<sup>a</sup>Matches were determined according to the criteria shown in Table 1.

there is a subgroup of opiate users, perhaps defined by socioeconomic status, with a decreased probability of seeking treatment. All opiate users have an appreciable probability of being arrested because heroin use in Thailand is illegal and highly associated with prison history.<sup>1</sup> The extensive scope of the police arrest recapture ensured a wide sampling of arrested persons in the city. Our finding that 34.0% of persons included in the methadone treatment capture, compared with 45.4% in the police station capture, were 20 through 29 years old suggests a difference in sampling for the two captures. Although an analysis stratified by age group yielded an estimate very similar to the overall estimate of the number of opiate users (Table 3), it is possible that other important strata remain unidentified and may contribute to a biased estimate.

The fourth assumption is that the capture history of each member is accurate: all true matches and only true matches are identified. The use of urine testing in the recapture ensured a highly specific identification of recent opiate users. Matches from the two capture lists were identified primarily by name, age,

and date of birth. Gender was male for 94% of persons on both lists, and Thai national identification number, which was available for 79.9% of the persons on the first capture list but only 2.8% of those on the second list, was of limited value in matching. The great diversity of Thai names contributed to the specificity of the matching. Thai surnames, in the large majority of cases, are unique to each family and consequently are highly varied; thus it is extremely rare for two people to share the same forename and surname. Names reported to drug treatment programs are obtained from national identification cards and are therefore very accurate. The names reported at police stations generally are not verified by identification cards but are found to be largely reliable.

This study generated an estimate of the number of active opiate users in Bangkok at one point in time. Because we did not address the duration of injection drug use, we cannot estimate the number of persons in Bangkok who had ever injected drugs but who were not currently using heroin. However, a recent study of injection drug users in treatment in Bangkok found the average duration of use to be more than 8 years; only 11% had

started injecting within the previous 2 years.<sup>1</sup> Because extensive HIV-1 transmission among injection drug users in Bangkok began only in 1988, these data indicate that most injection drug users infected with HIV are included in our estimate of 12 000, based on the estimated population of 36 600 active opiate users.

HIV-1 seroprevalence among opiate users in Bangkok has been measured only among those who seek treatment. Insufficient data are available to determine whether HIV-1 seroprevalence among injection drug users seeking treatment in Bangkok differs from the rate among those who do not seek treatment. Nevertheless, as a substantial number of injection drug users enter the treatment population each year, the stability of HIV-1 seroprevalence documented from 1988 through 1993 supports the assumption that such a difference is unlikely to be great.

We estimate that there were 36 600 active opiate users in Bangkok in 1991, leading to an estimate of approximately 12 000 HIV-infected injection drug users, including 0.8% of all men aged 20 through 39 years. Through 1992, 1675 cases of AIDS had been reported in Thailand (population 55 million) via a well-established surveillance system; 1150 cases (69%) were reported in 1992 alone, indicating a rapid increase in AIDS cases. In 1992, injection drug users accounted for 103 (9%) of new AIDS cases (Division of Epidemiology, Thai Ministry of Public Health, unpublished data). In the coming years, the number of cases of AIDS and other HIV-related diseases, including tuberculosis, arising from the present HIV-infected population of injection drug users will rise dramatically, placing new demands on existing health care facilities. Controlling HIV transmission among members of this population and their sexual partners will be important in limiting the AIDS epidemic in Bangkok. □

## Acknowledgments

This paper was presented in part at the Eighth International Conference on AIDS/Third Sexually Transmitted Disease World Congress, July 19–24, 1992, Amsterdam, the Netherlands.

We thank Dr Roel A. Coutinho, Dr J. Arthur Woodward, Dr Vichai Poshychinda, Dr Robert Byers, and Mark VanLandingham for their guidance in developing this study and Drs Timothy J. Dondero, Phillip Nieburg, and Glen A. Satten for reviewing the manuscript. We are grateful to Police Lt Gen Chavalit Yodmani, Dr Suchint Phalakornkule, Dr Sithaman Muttamara, Dr Kowit Wongpanich, Dr Suwat Chanchamnong, Dr Sudchai Panyarachun, Dr Thamnoon Vaniyapong, Dr Prawat

Pisesskolkit, Dr Virasak Vachatith, Dr Wonchat Subhaturas, Dr Sittichat Puttiprasert, Dr Jidbhong Jayavas, and Dr Pralom Sakuntanaga for their invaluable support. We also thank Siree Bunnag, M.L. Araya Sirodom, Vichet Puthaviriyakorn, Warunyupa Suwannadath, Sathit Sujarita, Busakorn Wongsuwan, Dr Pongvipa Lohsomboom, Dr Boondee Atikij, Baranee Mingmuang, Janjao Witt, and Mancharree Junk for their assistance in conducting this study. In addition, we are indebted to the staff of the Department of Health, Bangkok Metropolitan Administration, and the Technical and Research Section, Office of the Narcotics Control Board, for data and specimen collection; the laboratory staff of Than-yarak Hospital for specimen testing; and the personnel of the Bangkok Police Department for their cooperation.

We are grateful to Albert L. Bryant and Robert D. Griffiths and acknowledge the Narcotics Affairs Section of the US Embassy in Bangkok for financial support toward the cost of urine testing reagents.

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## Call for Abstracts for Epidemiology Late-Breaker Sessions

### Oral Exchange Session

The Epidemiology Section will sponsor a late-breaker epidemiology oral exchange session on Wednesday, November 2, 1994, during the American Public Health Association's annual meeting October 30 through November 3 in Washington, DC. The exchange will provide a forum for the oral presentation of investigations, analyses, or methods that have been conceived, conducted, and/or completed so recently that authors could not meet the deadline (February 10, 1994) for regular submission to other epidemiology sessions.

Abstracts of fewer than 200 words (any format) and a stamped, self-addressed return envelope should be submitted to Polly A. Marchbanks, PhD, Chief, EIS Program, Centers for Disease Control and Prevention, Mailstop C-08, 1600 Clifton Rd, Atlanta, GA 30333; (404) 639-3588.

Abstracts must be *received* by September 12, 1994. Decisions will be made by September 19, 1994.

### Poster Session

The Epidemiology Section will again sponsor a late-breaker poster session on Wednesday, November 2, 1994, at the APHA annual meeting October 30 through November 3 in Washington, DC. This session permits the presentation of work that has been completed too late in the last year for regular paper submission. Abstracts should report on work conducted during the last 6 to 12 months.

With a stamped, self-addressed return envelope (or e-mail return address), abstracts of less than 200 words (any format) should be submitted to Cathey Falvo, MD, MPH, Graduate School of Health Sciences, New York Medical College, Valhalla, NY 10595; tel (914) 993-4323; fax (914) 993-4434; falvo@nymc.edu (internet).

Abstracts must be *received* by September 12, 1994. Decisions will be made by September 19, 1994.