COST ANALYSIS OF TUBERCULOSIS CASE MANAGEMENT IN TWO OREGON COUNTIES

by

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Abstract

Nurse case managers provide an important supportive function in the provision of directly observed therapy to tuberculosis patients. Case management costs have not previously been reported in the literature. This study aimed to establish an estimate of the cost per patient for nurse case management in Oregon. The state health department currently provides monetary support to counties for case management, to encourage uniformity in tuberculosis control. We evaluated the adequacy of these funds. Nurse case managers were selected from Multnomah and Marion County health departments to collect data on the amount of time each TB patient required per week. These data were merged with patient information from public health records. Mixed effects modeling techniques were used to identify patient factors associated with case management time. Mean and predicted costs were calculated.

The factors associated with increased case management time were non-compliance with directly observed therapy, the use of incentives, and the presence of one of several important treatment factors (e.g. an adverse reaction). The mean case management cost was $4831. Cost predictions for a standard treatment ranged from $2932 for the simplest case to $6530 for a complex one. After including outreach worker time, the average personnel cost increased to $5979 with predictions ranging from $4052 to $7721. These estimates are substantially higher than the current available state funding for case management. Using these data, more informed budget decisions can be made to allot appropriate amounts of money to the county health departments for TB control.

Background

Since 1989, the Centers for Disease Control and Prevention have recommended that active Tuberculosis (TB) patients in the United States receive Directly Observed Therapy (DOT).[1] In DOT, case workers meet with patients to administer drug doses under direct supervision. Patients are often assigned a Nurse Case Manager (NCM) to monitor their treatment progress, and an Outreach Worker (OW) to deliver drugs.[2,3] Many studies have shown that DOT increases adherence to treatment, improves outcomes, and reduces medical expenditures.[1,5-10] Oregon State, which adopted DOT as its standard of care in the 1990s, has one of the lowest TB incidence rates in country.[2-4] Several studies have shown DOT to be a cost-effective treatment option,[5,11-13] although cost-effectiveness in low incidence states, such as Oregon, remains unexplored. In order for public health authorities to advocate for essential TB funding and appropriately allocate these funds, an accurate accounting of case management costs is necessary. Enhanced state support will allow the county health departments to maintain a uniform DOT program across Oregon.

Funding for TB control activities comes from a combination of the state and local health departments (S. Schafer, HST Program, Oregon Department of Human Services, "personal communication," Sept 16, 2006). NCM salaries, which account for a substantial portion of DOT costs, are primarily funded by the county, with limited support from the state TB Program.[2] Although case management costs have not previously been studied in Oregon or other states, [6,10,14-15] the state health department provides approximately $1000 per case for case management (S. Schafer, HST Program, Oregon Department of Human Services, "personal communication," March 21, 2006).

This sum is believed to substantially underestimate case management expenses, placing the financial burden of DOT on the county health departments.

The existing literature on DOT costs indicates considerable variation, which raises concerns about the accuracy and reliability of the estimates therein.[5-14] In addition, these estimates may not reflect current circumstances due to rapidly rising costs, secular changes in the health care system, and reduced hospitalization rates. Since most of the analyses were conducted prior to wide acceptance of DOT, expenses need to be reevaluated under the current treatment paradigm. In the most recent study reviewed, Porco et al.[15] found the cost of administering DOT to be higher than previously reported (adjusted to 2006 dollars). They estimated the cost of treating latent infection in newly-arrived immigrants in California, using Medicare and Medi-Cal reimbursement rates. DOT was reported to cost about $130 per week or $3,528 (values in 2006 dollars) for a six month treatment. The authors did not include case management in their assessment since the study dealt with the treatment of latent infection.

Our study was designed to establish a reasonable estimate of DOT personnel costs for TB treatment. We aimed to measure the amount of time spent by NCMs and OWs per case in Oregon, as well as determine significant predictors of increased case management time and cost. We expected NCM time to vary temporally, but it was not known what treatment factors might be associated. A basic understanding of TB treatment costs and their determinants would be useful in making predictions for individual patients. If the case management costs associated with a new patient's characteristics could be predicted, the state health department could better estimate and advocate for appropriate funding to the counties, further improving the outcomes of DOT.

Methods

Data Collection

In late 2005, the TB Program at the Oregon Department of Human Services developed a worksheet to determine DOT case management time. Since Multnomah and Marion Counties produce the majority of TB cases in Oregon, they were the focus of this study.[4] A convenience sample of six NCMs was selected from Multnomah and Marion County health departments to document the work hours and treatment details for each TB case in their care, from February to August, 2006. The NCMs completed the worksheets weekly for each patient. They included estimates of weekly time dedicated to specific elements of TB case management including phone calls, contact investigations, office work, field visits, driving time, and miscellaneous time. The time contribution of outreach workers, who generally did the direct observation, was also reported by the NCM on the worksheet. Patient characteristics reported by the NCMs were: DOT status; treatment frequency; number of medications; the use of incentives and enablers such as coupons or rent money; adverse drug reactions; homelessness; and co-morbidity with an immune compromising condition. Worksheets were completed for all patients in care during the study period. Patients contributed varying numbers of patient-weeks to the dataset depending on when they began treatment.

In Oregon, providers must report confirmed and suspected TB cases to the state health department.[16] Standardized demographic and clinical data regarding active TB cases are entered into the TB Information Management System (TIMS) (Division of TB Elimination, CDC, Atlanta, GA), which stores pertinent information for surveillance, case management and public health practice. Thus, each confirmed cases of TB followed

during data collection had a matching record in the TIMS database. State case numbers were used to reference these patient records which included information such as age, sex, race, citizenship, HIV status, treatment location, homelessness, and diagnostic results from chest x-rays, sputum cultures, and drug susceptibility tests.

Data Management

The case management dataset was first cleaned and checked for errors. We then merged it with a dataset exported from the TIMS database using SAS software version 9.1 (SAS Institute, Inc., Cary/NC, 2006). Records absent from the TIMS database were excluded from analysis. Data collected after week 30 were also excluded, since this extended beyond the standard duration of treatment. Patients receiving extended treatment were believed to be inherently different from those being treated in the first 30 weeks.

We explored two major outcome variables in our analysis: total NCM time and OW time. Each outcome was measured in hours spent per case per week. The primary variable in our analysis was total NCM time, which included all of the time spent on patient-specific DOT activities as well as time spent on miscellaneous administrative activities. The miscellaneous time component of total NCM time, which was not attributable to any one patient, was distributed over all of the cases the NCM reported working with in a given week. OW time, which included all OW activities, was also of importance since it was a major component of DOT personnel costs.

The variables assessed in single variable analysis are presented in table 1. Several variables were recoded as dichotomous variables while others were combined to improve

their utility in the analysis. We combined several variables with small subgroups and a similar effect on NCM time, including HIV status, rifampin resistance, homelessness, and adverse reaction to drugs, to represent the presence of an important 'other factor.' Treatment week was compressed into four phases to better model the changing duties of the NCMs at natural break points during therapy. The start-up phase was the first three weeks of DOT, which captured the turmoil of starting a new patient on therapy. The initial phase followed from week four to week ten. The continuation phase, marked by reevaluation and changes in the drug regimen, extended to week 30.

Statistical Analysis

Frequencies and histograms were examined to assess the distributional properties of each variable. Bivariable plots of total NCM and OW times by week of therapy were visually inspected. We evaluated differences in means between treatment phases and individual NCMs using interaction plots. Random effects were assessed graphically by comparing the relationship of NCM time with treatment week between patients. The average total NCM cost for a standard six month treatment was calculated by multiplying the mean total NCM time per week by 28 weeks.

Analyses were performed on the total NCM time. To help ameliorate skewed distributions and non-constant variance, both square root and natural log transformations were fitted. T-tests and F-tests were performed to determine whether statistical differences in NCM time existed between different patient factor levels. We implemented a random patient effect to properly group the multiple observations on each individual patient and control for the resultant correlation between data points.[17]

To properly judge the significance of each independent variable, we individually entered them into a linear mixed effects model containing the treatment phase and random patient effect. All variables significant at the 0.10 level were entered into a large, multivariable model. We refined this multivariable model using backwards selection. Diagnostic plots were used to identify and remove concerning outliers. We also explored plausible interactions. Lastly, we compared the fit of models containing the natural log transformation of NCM time, the square root transformation NCM time, and untransformed NCM time.

To introduce the effect of individual case managers on the total NCM time per week into the model, we used an additional random effect. This allowed us to account for correlation between patients under the same case manager and also make general predictions outside of the six NCMs involved in this study.[18] The random patient effect was nested within the random NCM effect, resulting in a hierarchical model that indexed each observation to a specific patient within the care of a specific case manager. Since OW time was not our primary outcome and had a much smaller impact on cost, it was modeled simply using the means value from each treatment phase.

We then calculated the mean NCM and OW times for a standard 28 to 30 week treatment period. These were converted to dollar amounts using wage estimates of $31.73 per hour for NCMs and a $15 per hour for OWs.[19] To make useful cost predictions from our multivariable model, we created a set of hypothetical TB patients using different combinations of patient factors over the course of a typical treatment period. To accomplish this, we used the model to generate NCM time predictions for each week of treatment, based on the factors of interest present during each week. We then summed the

predictions to determine the total NCM time for a completed treatment. We predicted the 28 week OW time by summing the average total times spent per treatment phase. Confidence intervals were also created. The total time values were converted to dollar amounts using the above wages. To obtain the total personnel cost for a 28-week treatment, we added the predicted OW worker cost to the total predicted NCM cost.

Results

Forty-two patients were followed for varying periods of time, yielding 546 patient-weeks of observations. Plots of total NCM time versus treatment week revealed that time varied widely in the first several weeks (Figure 1). After three weeks, mean number of hours tapered off and the variability condensed. This trend continued through week eighteen, when the time values leveled off with relatively constant variance. The overall mean NCM time was 4.99 (SD: ±4.41) hours per week (Table 2). The average 28 week treatment required 152.2 (SD: ±130.9) hours of NCM time. Outreach worker time exhibited a slightly different pattern with lower variability (Figure 1). An increasing rather than decreasing trend was evidenced in the first several weeks that reached a plateau and declined after week nine. The temporal trend was relatively weak. The mean time was 2.82 (SD: ±2.92) hours per week and the average 28 week treatment took 76.6 (SD: ±82.1) hours of OW time. The treatment phase means for total NCM and OW time are listed in table 2.

Variables significantly associated with total NCM time in bivariable analyses are presented in table 1. Multivariable model building revealed the most important fixed factors to be treatment phase, incentive use, patient compliance to the prescribed drug regimen, the presence of 'other' patient factors and the case load of the NCM in a given week. However, due to its weak effect and difficulty using it for predictions, the number of cases per week was removed. None of the interactions tested were significant at the 0.10 level. The resulting mixed effects model is summarized in table 3.

Progress from one treatment phase to the next was significantly associated with a decrease in NCM time. DOT during the initial phase took about 0.27 fewer NCM hours

per week than during the start-up phase. During the continuation phase, NCM time was 0.36 hours lower than in the start-up phase. The presence of each significant patient factor was associated with increased NCM time. A non-compliant patient required 0.34 hours more NCM time per week than a compliant one. Patients who were given incentives to promote treatment compliance took about 0.25 hours more NCM time per week than patients not receiving incentives. The presence of an 'other' factor was associated with an additional 0.25 hours of NCM time per week over patients without 'other' factors.

The average patient in this dataset received 152.3 (95% CI: 139.3, 165.2) hours of NCM attention, which translated to $4831 (95% CI: 4419, 5243) at $31.73 per hour. We calculated that OWs contributed an average of 76.6 (95% CI: 68.4, 84.7) hours per completed treatment, amounting to $1149 (95% CI: 1026, 1271). Combined, the average total DOT personnel cost was $5979 (95% CI: 5519, 6440). Our hypothetical TB treatment scenarios and model predictions, which explored the costs associated with each patient factor, are summarized in table 4. For a new TB patient who lacked all three significant patient factors for the entire treatment period, the total predicted amount of NCM time would be 92.4 hours, which translates to $2932 (95% CI: 1837, 4466). An OW would spend an additional 74.7 hours, which would cost $1120 (95% CI: 932, 1308). Therefore, the total DOT personnel cost for this case would be $4052 (95% CI: 2954, 5150).

When we added an 'other' factor for the extent of the 28 week treatment, the total predicted NCM time increased to 132.6 hours, equivalent to $4208 (95% CI: 2733, 6283). The estimated OW cost remained constant, leading to a total combined cost of

$5328 (95% CI: 3126, 7530). A TB case with no 'other' characteristics but who was offered incentives every week was predicted to require 132.8 hours of NCM time, which would cost $4214 (95% CI: 2717, 6332). The total personnel costs would be $5334 (95% CI: 3132, 7535). For a case that had an important 'other' factor and received incentives throughout the 28 week treatment period, it was predicted that 186.5 hours of case management would be required. This would cost $5916 (95% CI: 3934, 8714) and combined with the estimated OW time, the DOT personnel for this case would cost $7036 (95% CI: 4516, 9557).

Patients that were non-compliant required more time to manage. We considered a hypothetical patient with an 'other' factor who received incentives for the entire treatment and was not fully compliant during two weeks of the continuation phase. After we extended the treatment to 30 weeks to compensate for missed doses, this patient had a predicted NCM time of 205.8 hours along with 79.4 hours of OW time. These services cost $6530 (95% CI: 4296, 9726) and $1191 (95% CI: 994, 1389), respectively. The total personnel cost was $7721 (95% CI: 5521, 9921). The last case was the worst case scenario, within the confines of our model. This patient had 'other' factors, was given incentives, and was non-compliant throughout their entire 30 week course of treatment. Since these conditions did not occur within the dataset, the prediction was an extrapolation and therefore highly uncertain. The actual costs were probably underestimated considerably, given that a TB patient who misses a large number of doses will have a much longer treatment, may have a worsening condition, and may develop drug resistance. The model predicted that such a patient would require 317.3 hours of NCM time with an estimated 79.4 hours of OW time, which would cost $10,068 and

$1191, respectively. The total predicted personnel costs would be $11,259. Confidence intervals could not be calculated.

Discussion

We found that the most important factors associated with TB case management time per patient per week were: the treatment phase of the patient; whether or not the patient possessed one of several clinically significant 'other factors;' whether or not the patient was offered incentives or enablers; and whether or not the patient was compliant with DOT. Our results showed that the average TB case required 152.3 hours of NCM time for a standard 28 week treatment, costing $4831. Additionally, OW services cost an average of $1120 per case. The presence of an 'other' factor required an estimated $1276 per patient after controlling for all else, while the use of treatment incentives added $1282. If a patient had both an 'other' factor and received incentives, then they required an additional $2984 for case management.

These significant factors make intuitive sense. Due to differing drug regimens and patient activities during each treatment phase, NCM time varied temporally. NCMs spent more time with non-compliant patients to reinitiate antibiotic treatment and manage the clinical consequences of lapses. Patients with indications such as a positive sputum culture, HIV co-infection, rifampin resistance, adverse reaction to drugs, or homelessness demanded more attention from their case manager. Cases involving treatment incentives required additional monitoring for compliance and extra administrative duties, both of which necessitated more NCM time.

The large differences in time recorded by the six NCMs that participated in the study were not surprising. Recall and efficiency were expected to vary among personnel. NCM was reentered into the model as a random effect to enhance the interpretability of the results and allow predictions to be made for all Oregon NCMs. The removal of the

variable representing the number of cases managed per week was also justified in terms of improving the utility of the model and creating parsimony. The observed effect of this variable was quite small and its significance could have been an artifact of the survey design or computation of the variable.

Several limitations in the study design and data collection are important to consider as caveats to cost estimates produced by this analysis. The study design did not establish a standard follow up period for patients, which resulted in large variations in the number of observations and the treatment weeks in which they were made. Although this type of heterogeneity may lead to invalid comparisons between disparate individuals, the consequences were reduced by excluding observations above week 30. Unfortunately, by excluding these cases, the small subset of patients requiring extended therapy was not explored. The worst case scenario of $11,259 arrived at by this study was extrapolated from conditions not present in the dataset. In addition, the study relied on self-reported work hours from the participating NCMs. It is possible that over-reporting of NCM time caused a self-report bias, although this bias would be expected to be similar among all NCMs and serve only to bias associations toward the null. Feasible alternatives to this method, that were reasonably cost-effective, did not exist.

The questionnaire used in data collection may limit the accuracy of the results since it was not validated in a separate population of case managers. It was, however, developed in conjunction with two Multnomah county NCMs to improve its clarity and ability to elicit precise estimates. Though specific activities were lined out to facilitate recall, NCMs only recorded the amount of time spent with each patient once per week. Recall bias may have resulted from variations in case load. NCMs with challenging patients may

have more accurately remembered the amount of time spent working with them. Moreover, busy NCMs with a large case load may have had worse recall than those working on only one or two cases.

Although the small sample size of 42 cases was enhanced with a longitudinal design, it is possible that these individuals differ in important ways from the greater population of TB patients in Oregon. Data collection was further limited to Multnomah and Marion counties which may not be representative of case management practices in other parts of Oregon, including low incidence and rural counties. Furthermore, these data may not be generalizeable outside of Oregon, as NCM practices, DOT delivery, and public health infrastructure differ between states.

Despite these limitations, the estimates and predictions are valid and may prove to be useful for budgeting. The state health department currently provides approximately $1000 for case management per TB patient, which is substantially lower than the average cost of $4831 in Multnomah and Marion Counties. Even a fully compliant, uncomplicated case treated for 28 weeks cost $2932, nearly 300% more than the current allocation. Given no information about a new TB case, the average makes a reasonable point estimate for the funding required by a county health department for case management. If patient information is known, counties can improve the precision of the estimate substantially.

Although they cannot predict whether a patient will be compliant or not, NCMs can ascertain whether or not 'other' important clinical factors are present. From their own experiences, NCMs can also judge whether incentives will be necessary to retain a given patient. This basic evaluation of new TB cases will allow counties to request and the state

to provide reasonable support for case management. Ultimately, this evidence will give the state the information necessary to lobby for additional TB control funding. This strategy of rational resource allocation will help NCMs produce a consistent level of care across Oregon and ensure that every TB case finishes a full course of treatment successfully. These features will minimize the risk of drug resistant infections and contribute to the continuing move toward TB elimination in Oregon.

Data collection on NCM and OW time should continue in order to evaluate the adequacy of TB Program support for counties to administer effective DOT programs. The data collection methods and modeling techniques used in this study should be repeated in this population and others. Future studies with larger samples of TB patients should identify further patient factors important in predicting NCM costs. The model developed in this analysis should also be validated and the effect estimates refined. The worst case scenario prediction of $11,259 provided an upper bound to the estimated DOT costs in this study but was based on extrapolated conditions not present in the dataset. Challenging patients being treated beyond 30 weeks should be studied more closely to refine this value.

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Table 1- Patient Characteristics and Total NCM Time Per Week (in Hours)

Patient Characteristic	N (%)[a] or Mean ± SD	Total NCM Time Per Week: Mean ± SD	Total NCM Time Per Week: Adjusted P-Value Week<31[b]
Treatment Week	16.48 ± 11.58	--	--
Cases Per Week	6.67 ± 2.64	--	0.0002*
Age Group (years old)	40-44[c]	--	0.5063
Treatment Phase			<.0001*[d]
Start-Up (Weeks 1-3)	58 (12.18)	9.25 ± 6.95	
Initial (Weeks 4-10)	118 (24.79)	5.51 ± 4.10	
Continuation (Weeks 11-30)	228 (47.90)	4.33 ± 3.51	
Extended (Weeks 31+)	72 (15.13)	2.78 ± 1.60	
Case Manager			<.0001*
1	124 (26.05)	4.73 ± 4.58	
2	159 (33.40)	6.54 ± 4.87	
3	11 (2.31)	11.05 ± 3.86	
4	63 (13.24)	5.05 ± 3.01	
5	31 (6.51)	2.36 ± 1.86	
6	88 (18.49)	2.68 ± 2.65	
County			0.0017*
Marion	119 (25.00)	2.60 ± 2.46	
Multnomah	357 (75.00)	5.79 ± 4.62	
Gender			0.3955
Male	268 (56.30)	4.55 ± 3.59	
Female	208 (43.70)	5.56 ± 5.23	
Ethnicity			0.0396*
Hispanic	50 (10.50)	2.23 ± 1.61	
Non-Hispanic	426 (89.50)	5.31 ± 4.52	
Citizenship			0.7793
US	187 (39.29)	5.26 ± 5.20	
Non-US	289 (60.71)	4.81 ± 3.81	
Major Site of Disease			0.1285
Pulmonary	332 (69.75)	5.47 ± 4.92	
Extra-Pulmonary	144 (30.25)	3.88 ± 2.62	
Sputum Smear			0.7558
Positive	177 (37.18)	4.47 ± 3.31	
Negative	169 (35.50)	6.05 ± 5.75	
Sputum Culture			0.1000*
Positive	254 (53.36)	6.00 ± 5.12	
Negative	94 (19.75)	3.62 ± 3.10	
Chest X-Ray Result			0.1442
Normal	101 (21.22)	4.00 ± 2.85	
Abnormal	375 (78.78)	5.26 ± 4.71	
Skin Test Result			0.2764
Positive	343 (72.06)	5.19 ± 4.78	
Negative	45 (9.45)	3.57 ± 2.83	
HIV Status			0.7868
Positive	34 (7.14)	4.61 ± 3.09	
Negative	369 (77.52)	5.25 ± 4.68	
Initial Rifampin Resistance			0.6420
Resistant	14 (2.94)	6.55 ± 2.36	
Susceptible	351 (73.74)	5.06 ± 4.59	
Provider Type			0.9655
Health Department	169 (35.50)	4.63 ± 4.49	
Health Dept. & Private	135 (28.36)	3.88 ± 4.50	

Table 1 (cont.)- Patient Characteristics and Total NCM Time Per Week (in Hours)

		Total NCM Time Per Week	
Patient Characteristic	**N (%)[a] or Mean ± SD**	**Mean ± SD**	**Adjusted P-Value Week<31[b]**
Directly Observed Therapy			0.5442
Yes	438 (92.02)	5.09 ± 4.45	
No	38 (7.98)	3.87 ± 3.79	
DOT Site			0.0454*
Clinic	67 (14.08)	1.81 ± 1.20	
Field	139 (29.20)	5.24 ± 4.75	
Both	53 (11.13)	5.65 ± 5.97	
Drug Use			0.8995
Yes	95 (19.96)	5.03 ± 4.88	
No	355 (74.56)	4.70 ± 3.63	
Hospitalization			0.3079
Yes	11 (2.31)	9.88 ± 8.01	
No	465 (97.69)	4.88 ± 4.24	
Suspected TB Case			0.1369
Yes	19 (3.99)	6.07 ± 4.55	
No	457 (96.01)	4.95 ± 4.40	
Treatment Frequency			0.1192
0 Visits/Week	5 (1.05)	10.28 ± 7.05	
2 Visits/Week	165 (34.66)	3.40 ± 2.96	
3 Visits/Week	18 (3.78)	5.37 ± 5.09	
5 Visits/Week	288 (60.50)	5.79 ± 4.73	
Number of Drugs			0.4579
0 (Off Meds)	14 (2.94)	5.92 ± 5.33	
2 Antibiotics	262 (55.04)	3.84 ± 2.92	
3 Antibiotics	106 (22.27)	6.23 ± 5.22	
4 Antibiotics	94 (19.75)	6.64 ± 5.68	
Other Patient Factors[e]			0.0526*
Yes	322 (67.65)	5.65 ± 4.81	
No	154 (32.35)	3.61 ± 3.01	
Incentives			0.6890
Yes	148 (31.09)	5.86 ± 5.42	
No	328 (68.91)	4.60 ± 3.81	
Homeless in Past Year			0.4755
Yes	57 (11.97)	7.49 ± 5.19	
No	419 (88.03)	4.65 ± 4.19	
Co-morbidity			0.0335*
Yes	98 (20.59)	6.93 ± 5.26	
No	378 (79.41)	4.49 ± 4.02	
Adverse Reaction			0.2992
Yes	7 (1.47)	7.66 ± 3.98	
No	469 (98.53)	4.95 ± 4.41	
Non-Compliant			0.0575*
Yes	13 (2.73)	6.10 ± 3.65	
No	463 (97.27)	4.96 ± 4.43	
Race			0.0744*
White	180 (37.82)	3.85 ± 3.97	
Other Race	296 (62.18)	5.68 ± 4.52	

* Variables significant at the 0.10 level and taken on to be tested in a multivariable model.

[a] Some percentage values in this column do not add to 100 due to missing data.

[b] Significance values were obtained from a mixed effect controlling for the random subject effect and treatment phase.

[c] Median age group.

[d] Treatment phase was fitted in a univariable mixed model against the outcome.

[e] Variable includes factors that similarly affected NCM time: HIV status, sputum culture result, rifampin resistance, homelessness, and adverse reaction to TB medications.

Table 2- Mean and Median Hours of DOT Personnel Time Per Week By Treatment Phase (n=476)

Outcome Variable	Mean ± SD	Median
Total NCM Time[a]	4.99 ± 4.41	3.71
Start-Up Phase (Weeks 1-3)	9.25 ± 6.95	7.25
Initial Phase (Weeks 4-10)	5.51 ± 4.10	4.50
Continuation Phase (Weeks 11-30)	4.33 ± 3.51	3.43
Extended Phase (Weeks 31+)	2.78 ± 1.60	2.63
28-week Treatment	152.2 ± 130.9	--
Total Outreach Worker Time[b]	2.82 ± 2.92	2.82
Start-Up Phase (Weeks 1-3)	2.90 ± 2.86	2.50
Initial Phase (Weeks 4-10)	3.33 ± 3.59	2.50
Continuation Phase (Weeks 11-30)	2.37 ± 2.46	1.50
Extended Phase (Weeks 31+)	3.36 ± 2.93	3.50
28-week Treatment	76.57 ± 82.11	--

[a] Total NCM time spent per patient per week including miscellaneous time per case.
[b] Total amount of outreach worker time per patient per week.

Table 3- Significant Mixed Effects Model for Total NCM Time Per Week (Treatment Week<31) With Random Subject and NCM Effects[a]

Fixed Effect	Parameter Estimate	Std. Error	Computed Effect[c] (95% CI)	Computed Cost[d] (95% CI)	P-Value
Intercept	2.8063	0.2463	15.55 (15.06, 16.03)	493.40 (478.03, 508.78)	<.0001
Treatment Phase					
Start-Up	0[b]	--	0[b]	0[b]	--
Initial	-0.3170	0.0678	0.27 (-0.40, -0.14)	8.62 (-12.85, -4.39)	<.0001
Continuation	-0.4394	0.0657	0.36 (-0.48, -0.23)	11.28 (-15.38, -7.18)	<.0001
Non-Compliant					
Yes	0[b]	--	0[b]	0[b]	--
No	-0.41850	0.16470	0.34 (-0.67, -0.02)	10.85 (-21.13, -0.57)	0.0115
Other Patient Factors[e]					
Yes	0[b]	--	0[b]	0[b]	--
No	-0.2882	0.0504	0.25 (-0.35, -0.15)	7.94 (-11.09, -4.80)	<.0001
Incentives					
Yes	0[b]	--	0[b]	0[b]	--
No	-0.2893	0.0492	0.25 (-0.35, -0.15)	7.97 (-11.04, -4.90)	<.0001

[a] The outcome of the mixed model was log transformed: ln(Total NCM Time + 1). The random effects structure was hierarchical with the patient ID nested within their case manager.

[b] Referent categories are set to zero.

[c] Effect on total NCM time per week, in hours, computed by un-transforming the parameter estimate ($e^{\beta i}$ - 1).

[d] Effect on NCM cost, in 2006 dollars, per week of treatment.

[e] Other patient factors include HIV status, sputum culture result, rifampin resistance, homelessness, and adverse reaction to TB medications.

Table 4- Cost Predictions for Hypothetical TB Patients - Calculated from Mixed Model Predictions and Outreach Worker Treatment Phase Means

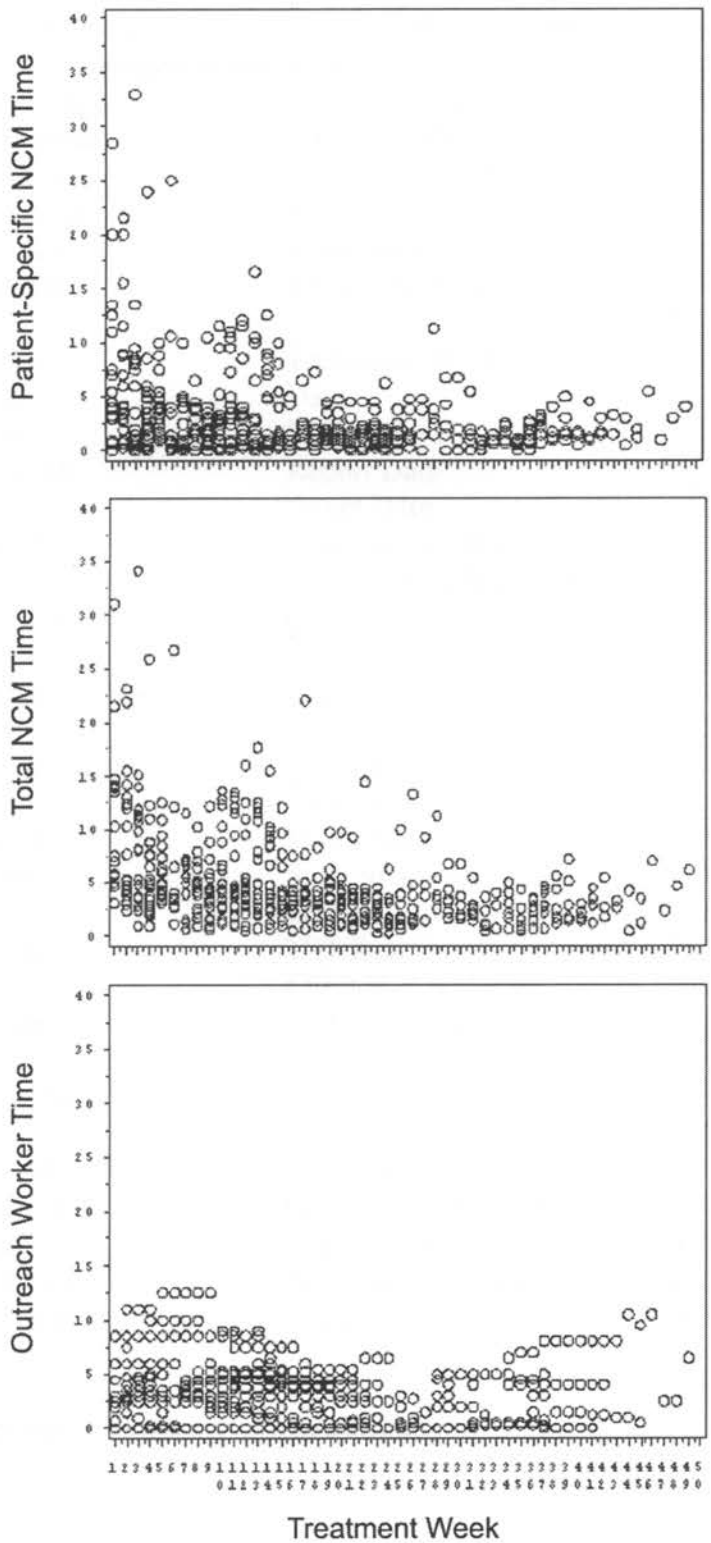
	Mixed Model Predictor Variables			Model Predictions and Interval Calculations		
Scenario (Treatment Length)	**Other Factors (Duration)**	**Incentives (Duration)**	**Non-Compliance (Duration)**	**NCM Time (95% CI) in Hours**	**NCM Cost (95% CI) in USD[a]**	**Total Personnel Costs (95% CI) in USD[b]**
Average (28 Weeks)	--	--	--	152.2 (139.3,165.2)	4831 (4419, 5243)	5979 (5438, 6521)
Patient 1 (28 Weeks)	No (All Phases)	No (All Phases)	No (All Phases)	92.4 (57.9, 140.7)	2932 (1837, 4466)	4052 (2954, 5150)
Patient 2 (28 Weeks)	Yes (All Phases)	No (All Phases)	No (All Phases)	132.6 (86.1, 198.0)	4208 (2733, 6283)	5328 (3126, 7530)
Patient 3 (28 Weeks)	No (All Phases)	Yes (All Phases)	No (All Phases)	132.8 (85.6, 199.6)	4214 (2717, 6332)	5334 (3132, 7536)
Patient 4 (28 Weeks)	Yes (All Phases)	Yes (All Phases)	No (All Phases)	186.5 (124.0, 274.6)	5916 (3934, 8714)	7036 (4516, 9557)
Patient 5 (30 Weeks)	Yes (All Phases)	Yes (All Phases)	Yes (Week 15-16)	205.8 (135.4, 306.5)	6530 (4296, 9726)	7721 (5521, 9921)
Patient 6 (30 Weeks)	Yes (All Phases)	Yes (All Phases)	Yes (All Phases)	317.3[c]	10,068[c]	11,259[c]

[a] NCM costs are based on a wage of $31.73 per hour.

[b] The total estimated cost of both NCM and OW time. OW costs are based on a wage of $15 per hour.

[c] Confidence intervals could not be computed due to extrapolated predictions.

Figure 1– Plots of patient-specific NCM time, total NCM time and outreach worker time by treatment week (in hours)



Appendix 1- Data Dictionary

Variable	Label	Values
tottimenomisc	Patient-Specific CM Time	0-∞
totoutrchtime	Outreach Worker Time	0-∞
miscellaneouscasmgmt	Misc CM Time	0-∞
misctimpc	Misc CM Time Per Case	0-∞
totcmtime	Total CM Time	0-∞
totdottime	Total DOT Time	0-∞
rttottime	Root CM Time	0-∞
rtouttime	Root Outreach Worker Time	0-∞
rttotcmtime	Root Total CM Time	0-∞
id		1-42
week	Treatment Week	1-50
date	Date	--
dob	Date of Birth	--
reportdt	Report Date	--
countdt	Count Date	--
rxdate	Date Therapy Started	--
stopther	Date Therapy Stopped	--
cpw	Cases Per Week	1-∞, # cases worked on by designated CM in a given week
county	County	Marion, Multnomah
sex	Gender	1=Male, 2=Female
ethnic	Ethnicity	1=Hispanic, 2=Non Hispanic
uscitizn	US Citizen	0=Not US, 1=US
majorst	Major Site of Disease	0=Pulmonary, 1=Extra-Pulmonary
spsmear	Sputum Smear	1=Positive, 2=Negative
spcult	Sputum Culture	1=Positive, 2=Negative
tbtest	TST Result	1=Positive, 2=Negative
xray	Chest X-Ray Result	1=Normal, 2=Abnormal
abnormal	CXR Cavitary	1=Cavitary, 2=Non cavitary consistent with TB
xraystat	CXR Change	1=Stable, 2=Worsening, 3=Improving
hivstat	HIV Status	0=Negative, 1=Positive
homeless	Homeless in Past Year	0=No, 1=Yes
inject	Injection Drug Use	0=No, 1=Yes
noninjct	Non-Injection Drug Use	0=No, 1=Yes
druguse	Drug Use	0=No – If inject=0 AND noninjct=0, 1=Yes – If inject=1 OR noninjct=1
agegrp	Age Group	1=0-4, 2=5-9, 3=10-14, 4=15-19, 5=20-25, 6=25-29, 7=30-34, 8=35-39, 9=40-44, 10=45-49, 11=50-54, 12=55-59, 13=60-64, 14=65-69,

		15=70-74, 16=75-79, 17=80-84, 18=85+
isusrif	Initial Rifampin Resistance	1=Resistant, 2=Susceptible
provtype	Provider Type	1=Health Dept, 2=Private, 3=Both
dirsite	DOT Site	1=Clinic, 2= Field, 3=Both, 9=Unknown
racecalc	Race Group	0=White, 11=Other Race
txfreq	Treatment Frequency	0, 2, 3, 5
nudrgs	Number of Drugs	0, 2, 3, 4
dot	Directly Observed Therapy	0=No, 1=Yes
otherfactor	Other Patient Factors	0=No, 1=Yes – If details=other WHERE noncompliant=0, OR spcult=1, OR hivstat=1 OR isusrif=1, OR homeless=1, OR adverse=1
incentives	Incentives	0=No, 1=Yes
prevtb	Previous TB Diagnosis	1=Yes, 2=No
hospitalization	Hospitalization for TB	
comorbid	Comorbidity With Immune-Compromising Disease	
adverse	Adverse Reaction to Antibiotics	0=No, 1=Yes
suspect	Suspect/Unconfirmed TB Case	0=No, 1=Yes
noncompliant	Patient Non-Compliance	0=No, 1=Yes
txphase	Treatment Phase	1=Start-Up – If week=1 to 3, 2=Initial – If week=4 to 10, 3=Continuation – If week=11 to 30, 4=Extended – If week>30

Appendix 2- NCM Data Collection Form/Questionnaire

***Reminder: Use one form per case. Fill out one column at the end of each week of treatment until the case is closed. Beginning in the middle of treatment is okay. Add sheets as necessary for additional weeks. Fax completed forms to Oregon TB Program 971-673-0178 Attn: Sean Schafer.**

Client ID Number _____

1. Case Manager Initials:					
2. Date	/ /	/ /	/ /	/ /	/ /
3. Treatment Week(e.g. 1 to nth week)	(n/a ☐)	(n/a ☐)	(n/a ☐)	(n/a ☐)	(n/a ☐)
4. Treatment Frequency	Daily ☐ 2/wk ☐ 3/wk ☐ not on meds ☐ _____ ☐ (other)	Daily ☐ 2/wk ☐ 3/wk ☐ not on meds ☐ _____ ☐ (other)	Daily ☐ 2/wk ☐ 3/wk ☐ not on meds ☐ _____ ☐ (other)	Daily ☐ 2/wk ☐ 3/wk ☐ not on meds ☐ _____ ☐ (other)	Daily ☐ 2/wk ☐ 3/wk ☐ not on meds ☐ _____ ☐ (other)
5. Number of drugs	None ☐ 2☐ 4☐ _____ ☐ (other)	None ☐ 2☐ 4☐ _____ ☐ (other)	None ☐ 2☐ 4☐ _____ ☐ (other)	None ☐ 2☐ 4☐ _____ ☐ (other)	None ☐ 2☐ 4☐ _____ ☐ (other)
6. Case details within current week					
DOT?	☐	☐	☐	☐	☐
Suspect (unconfirmed) case?	☐	☐	☐	☐	☐
Adverse effects of TB drugs?	☐	☐	☐	☐	☐
Co-Morbidity (high risk case)?	☐	☐	☐	☐	☐
Hospitalization?	☐	☐	☐	☐	☐
Incarceration?	☐	☐	☐	☐	☐
Homelessness?	☐	☐	☐	☐	☐
Incentives used?	☐	☐	☐	☐	☐
Other-please list?	☐	☐	☐	☐	☐
(Mark items 7–9 to the nearest ¼ hour—excluding driving time [see item 10 below])					
7. Phone Calls (hrs) To Patient or Family)	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
To Case Contacts	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
To Outside Care Providers	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
To Other Public Health Staff	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
Other (Please List)	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
8. Field Visits (hrs) To Patient (e.g. assessments, interviews)	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
To Case Contacts	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
Other-please list	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
9. Office Work/Visits (hrs)					
Clinic Visits with Patient	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
Clinic/office Visits with Contacts	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
Charting	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
Desk/Administrative (e.g. coordinating housing incentives, negotiating DOT)	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
Discussion with medical staff in addition to clinic visits	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
Other-please list	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
10. Driving Time Sum of case manager driving time for this patient during this week. (Estimate outreach worker driving time below in Item 12.)	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
11. Miscellaneous Case Management Activities Not Specific to Any Individual Case (This estimate will necessarily be the same for all patients in your case load for the week.)	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
12. Outreach Worker Hours (Estimate to nearest ¼ hr.) Sum of all outreach worker time spent on activities relating to this patient during this week (e.g. DOT, med prep, locating pt., social support, etc.) **not including driving time**	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
Driving Time	(h)	(h)	(h)	(h)	(h)
13. Translator Hours County Staff	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)
Outside Translator Service	_____(h)	_____(h)	_____(h)	_____(h)	_____(h)