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Costs and outcomes of tuberculosis control in the Russian Federation: retrospective cohort analysis

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We analysed costs and outcomes of tuberculosis care for patients in a traditional Russian tuberculosis control system, using 3-year retrospective cohort data. Of 1749 cases at 3 years of follow-up, 65% were cured, 11.3% (198/1749) still had 'active' or 'chronic' disease, 10.3% had transferred out of the local civilian health care system and 12.7% had died. The mean cost of managing one case over 3 years was US$886: US$1078 for bacteriologically confirmed (BK+) cases and US$718 for bacteriologically unconfirmed (BK−) cases. Approximately 60% of treatment costs were incurred in the first 12 months and 40% incurred in the remaining 2 years. Around 60% of the total cost was accounted for by hospital inpatient care.

The cost, treatment and outcome of BK+ and BK− cases differed substantially. The cost of treating BK+ cases was 50% higher than treating BK− cases due to higher hospitalization rates and the additional cost of managing BK+ cases that become 'chronic'. While BK+ cases accounted for 55% of total health expenditure on tuberculosis, the share of BK− cases was 45% of the total – due to hospitalization and lengthy periods of follow up.

The costs of treating tuberculosis in the Russian tuberculosis control system are very high compared with other high-burden countries due to hospitalization policies and lengthy case management periods. Much of this expenditure can be avoided if the WHO-recommended DOTS strategy is implemented. In particular, the proportion of expenditure for BK− cases is surprisingly high and can be avoided as most of these patients do not need hospitalizing or lengthy periods of follow-up.

Key words: tuberculosis, health systems, Russian Federation, economic evaluation

Introduction

The World Health Organization (WHO) DOTS management strategy has become the internationally recommended approach for tuberculosis (TB) control programmes (WHO 1997; Maher and Mikulencak 1999; WHO 2002a,b). To date, around 150 countries in the world have adopted the DOTS strategy, to varying degrees. Key measures of DOTS success (case detection and treatment success) are included in the Millennium Development Goals framework (Dye et al. 2005).

In the former Soviet Union (FSU) where TB is prevalent, only a limited number of WHO DOTS implementation programmes exist. Currently countries of the FSU report the lowest case detection rates (22%), with 9% of cases failing treatment and a death rate of 7% during treatment (Dye et al. 2005). For example, Russia has the ninth highest TB burden in the world in terms of the estimated incidence and is one of the 22 WHO high-burden countries for tuberculosis (WHO 2004). After a period of decline starting in the 1960s, the case notification rate fell to 34 per 100 000 population by 1990, but following the collapse of the Soviet Union, notification rates tripled, reaching 97 cases per 100 000 population in 2000 (Shilova et al. 2001; WHO 2004). In 2003, the incidence of and mortality from TB remained high at 83.2 and 21.8 per 100 000 population (WHO 2004).

Since 1995, demonstration projects implementing the WHO DOTS have been initiated in Russia with support from international and bilateral agencies – such as WHO, the World Bank and the UK Government's Department for International Development (DFID) – to support TB control. New regulations have been adopted recently to support implementation of standardized international practices in TB treatment (Ministry of Health 2003, 2004). However, by 2003 access to DOTS was limited to 27% of the population of Russia, compared with an average of 61% for the 22 high-burden countries.

TB case detection rates under DOTS in Russia remain low, at 6% in 2002 (WHO 2004).

Historically, Russia developed a comprehensive TB control system of prevention, case finding, diagnosis, treatment, post-treatment prophylaxis and rehabilitation. Case management was based on individualized treatment and the requirement to achieve lung cavity closure, in contrast to the DOTS approach which demands sputum conversion and standardized treatment completion as the cardinal measures of outcome success. The Russian classification for TB cases also differs from that defined by the WHO DOTS strategy as it relies on the presence of radiological abnormalities on chest X-rays detected through the national compulsory annual population screening with or without bacteriological confirmation detected (Drobniewski et al. 2002, 2004) (Box 1). Under the traditional Russian recording system, microbiological distinction is not made between sputum smear status and sputum culture status; positive results are recorded as 'bacillary-positive' (or BK+). Conversely, when both sputum and culture results are negative, patients are deemed 'bacillary-negative' (or BK−). Both BK+ and BK− patients are monitored using changes in chest X-ray appearance and clinical status. Particular features of TB control in the Russian Federation are the requirement to hospitalize newly detected cases, the use of lengthy and repeated hospitalizations of patients, and frequent use of surgery for pulmonary TB (WHO 2002c; Coker et al. 2003; Atun et al. 2005a,b; Floyd et al. 2006). The doses of the main first-line drugs and duration of chemotherapy vary from internationally accepted standard treatment regimens. The system also includes prolonged periods of follow-up and repetitive courses of anti-relapse therapy (Atun et al. 2005a; Coker et al. 2005). These contrast with the DOTS strategy which favours minimizing hospital

Box 1. Russian and WHO classification systems of adult tuberculosis cases

Russian classification system

Group 0 – Individuals with tuberculosis-like changes in the lungs of 'doubtful activity' who are not registered with the tuberculosis authorities under any other group. These can be defined as *tuberculosis suspects*, and in a well-functioning tuberculosis control system the proportion of this group among new notifications, as well as the rate of cancellation of tuberculosis diagnosis, is small. The diagnosis for this group is finalized within months from registration.

Group IA – active tuberculosis cases, including true new cases of tuberculosis as well as relapses. The Russian case classification does not distinguish between new cases and relapses after cure.

Group IB – failures of treatment and chronic tuberculosis cases, including both cases that are drug sensitive and cases that are drug resistant. The Russian case classification system does not routinely monitor drug resistance in the tuberculosis register.

Group II – cases whose condition is improving after the phase of active tuberculosis (Group IA). Usually, these are cases transferred from **Group IA**.

Group III – clinically cured pulmonary tuberculosis.

Group IV – individuals in contact with people who have active tuberculosis or with TB-infected livestock.

Group V – all extrapulmonary tuberculosis.

Group VII – individuals with residual changes in the lungs after treatment of pulmonary tuberculosis, and with increased risk of re-activation.

The new tuberculosis regulations introduced in late 2003 have fewer case management groups, with Group 0 expanded to include patients under investigation for tuberculosis, Group II expanded to include patients formerly included in Groups III and some of those included in Group V, active extrapulmonary cases (formerly in Group V) included in Group I, and Groups VI and VII abolished.

WHO definitions

Category I
New cases of smear-positive pulmonary tuberculosis and other newly diagnosed seriously ill patients with severe forms of tuberculosis.

Category II
Relapse and failure patients, those who interrupted treatment, and 'other' patients who were previously treated for more than 1 month not under a DOTS treatment programme.

Category III
New cases of smear-negative pulmonary tuberculosis and extra-pulmonary tuberculosis.

Source: Methodological guidelines for classification of persons registered at the tuberculosis dispensary facilities, Annex No. 5, Prikaz No. 324 (Ministry of Health 1995).

stays (Mawer et al. 2001; Borgdorff et al. 2002; WHO 2003).

The Russian TB control system consists of a large hierarchically structured network of specialized research institutions, TB dispensaries (comprehensive treatment and monitoring centres), specialty hospitals and inpatient wards in general hospitals, district TB physicians, clinical laboratories and sanatoria, comprising altogether 80 000 specialized TB beds (Ministry of Health 2002). This TB control system plays a substantial social care role. We have examined the reasons for the extensive use of hospital care elsewhere (Atun et al. 2005a,b,c; Floyd et. al. 2006).

Here we report the results of a detailed study examining costs and outcomes of traditional modes of treatment and care of newly diagnosed cases of pulmonary TB recruited to a cohort in 1999 and followed up for 3 years in Samara Oblast (region), Russia. Our study differs from earlier studies (WHO 2002c) in four ways. First, we map the trajectory of care pursued by each BK+ and BK− patient in our cohort over a period of 3 years, and analyse each and every intervention and contact with the health system. Secondly, we estimate total costs and outcomes over a period of 3 years for both these patient groups, the time it takes for a TB patient to complete treatment in the Russian System, as opposed to one year – the time horizon adopted by earlier studies. Thirdly, we discount costs, undertaking sensitivity analysis using undiscounted and discounted figures, using two different discount rates. Fourthly, we estimate cost and outcomes for BK− and BK+ patients over the 3-year period and compare these – in contrast to studies estimating cost and outcomes of TB control that focus on smear-positive patients (Borgdorff et al. 2002).

Samara Oblast has a population of 3.3 million with socio-economic indicators close to the Russian average. The trend in notification of new TB cases in the last decade in Samara mirrored that in Russia, tripling in the last decade and reaching, in 2001, a rate of 89.2 per 100 000 population (Coker et al. 2003). The region, which has a network of specialized outpatient and inpatient TB services, is the site of a collaborative project involving UK and Russian scientists supported by DFID. In 2001, implementation of WHO-approved methods of TB control was initiated. However, all patients in the cohort reported here were clinically managed according to the traditional Russian system of TB control.

Methods

Through a decree issued by the Samara Ministry of Health (SMOH), the research team was given access to two databases covering the period 1999–2002, the Regional Tuberculosis Register and the database of inpatient care episodes collected by the regional branch of the Federal Compulsory Health Insurance Fund. The first database contained information on notifications of TB cases, treatment progression, health outcomes, service utilization and patient transfers. The second database contained hospital discharge summaries for inpatient hospital episodes for TB. These two databases were integrated for analysis by matching individual patient information.

The cohort consisted of new adult (patients aged 16 years and over) pulmonary TB cases notified through 1999. For each of these patients, information on investigations, treatment and health status was collected for 3 years following notification.

Outcomes analysed included transformation of BK status, death from TB and TB-related causes, development of ‘chronic’ TB (transfers to Russian case management category 1B) and cure (defined here as transfers to ‘inactive’ Russian case management categories III or VII) (Box 1).

For cost analysis, we adopted a health service perspective. The unit costs of services were estimated using detailed financial data from the SMOH, and also included capital costs for equipment and buildings (estimated using average replacement costs). We triangulated these costs with the cost data available from the local Health Insurance Fund (HIF), discussed these with the economists and TB specialists working at the SMOH and the HIF to ensure accuracy, checked cost data from other related studies, and compared our cost data with those submitted by different Russian regions to the WHO Office in Russia. In our analysis we included 69% of the cases that had complete cost and outcome data and excluded from the study those that did not (see results section).

The cost of treatment was estimated for each case in the cohort on a monthly basis. We estimated cumulative mean treatment costs for the cohort and for selected subgroups over 12, 24 and 36 months after notification. We discounted costs by 3.5% and 5%, the rates used in other health systems (as there is no official discount rate used in the Russian Health System).

We used the Kaplan-Meier method (Kaplan and Meier 1958) to adjust for data censoring due to cases that dropped out of the cohort. This enabled us to take account of the changing denominator over the 3-year period. Cost data were adjusted for censoring using a non-parametric method by Lin (type 1) (Lin 2000; Raikou and McGuire 2004).

The study was approved by the Samara Regional Ethics Committee.

Results

Characteristics of the cohort

The number of new notifications of adult TB in 1999 was 2682 cases (Table 1). Of these, 2520 (94%) were pulmonary TB cases. Approximately 43% (1074) of newly notified adult pulmonary cases were BK+. Eighty per cent (2018/2520) of adult pulmonary TB cases notified in 1999 were men, with a mean age of 42 years.

Utilization and outcome data over 3 years were available for 69% (1749/2520) of the new adult pulmonary TB cases notified in 1999. These 1749 cases constitute our cohort. In terms of demographic features and clinical characteristics at notification, the cohort cases were similar to all adult pulmonary cases notified in 1999.

Table 1. Characteristics of the cohort and all new pulmonary tuberculosis cases notified in 1999

Parameter	Cases notified (1999)	Cohort studied (1999)
Total number of new pulmonary cases	2520	1749
Total number of new BK+ cases	1074	777
BK+, with lung cavities	750 (29.8%)	528 (30.2%)
BK+, with no lung cavities	324 (12.9%)	249 (14.2%)
Total number of new BK− cases	1446	972
BK−, with lung cavities	344 (13.7%)	191 (10.9%)
BK−, with no lung cavities	1102 (43.7%)	781 (44.7%)
Gender:		
Female	503 (20%)	434 (22.8%)
Male	2018 (80%)	1315 (75.2%)
Average age of the:		
Female	38.2	39
Male	40.7	44
Residence:		
Rural	483 (19%)	420 (24%)
Urban	2038 (80.8%)	1329 (76%)

Source: Regional Tuberculosis Service, official regional data on new notifications.

Follow-up

Outcomes including transfers out of the regional TB control system, removal from the register and death are shown for both BK+ and BK− groups in Figure 1. Over the 3 years of follow-up, approximately 8% (62/777) of BK+ cases were transferred out of the system (mainly due to migration) and 18.2% (95% CI, 15.6 to 21.2%) (135/777) died from TB or TB-related causes. The transfer out from the regional TB control system in the BK− cases was 12.1% (118/972), and death from TB and TB-related causes was 8.9% (95% CI, 8.2 to 12.3%) (87/972).

Clinical outcomes

The clinical progression of the cohort is shown in Figure 2. Estimated rates of outcomes adjusted for loss to follow-up are shown in Table 2.

The median time under treatment (Groups I and II) was 29 months for BK+ cases and 27 months for BK− cases (Figure 2).

Bacteriological response (from BK+ to BK−) occurred within the first 3 months of commencing treatment for 401 of the 777 BK+ cases, that is, 52% (95% CI, 46.9 to 56.8%) after adjusting for loss to follow-up. At 6 months the response rate was 67% (95% CI, 63 to 72%), and at 12 months was 78% (95% CI, 74 to 81%). Bacteriological response after 12 months was slow. Approaching 0.2% (18/972) of BK− cases became BK+ over 3 years of follow-up.

In the 3-year follow-up period, the death rate in the BK− cases was 10.4% (95% CI, 8.2 to 12.3%), compared with 18.2% (95% CI, 15.6 to 21.2%) in BK+ cases.

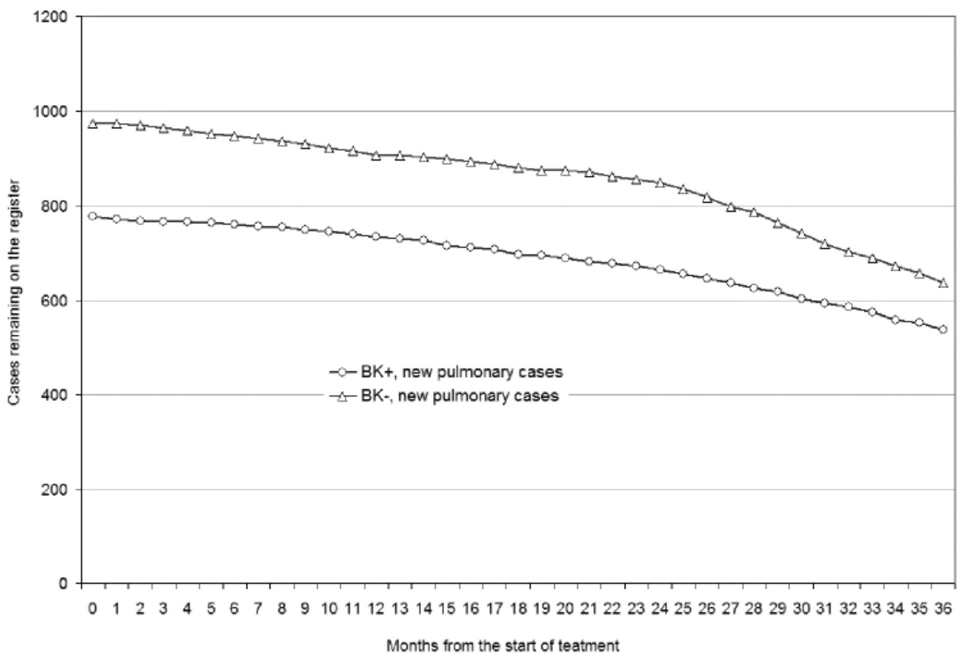


Figure 1. Loss to follow-up in the BK+ and BK− cases

Figure 3 shows Kaplan-Meier survival curves with 95% confidence intervals for the two groups of patients.

Most patients with pulmonary tuberculosis (79% of BK− cases and 82% of BK+ cases) remained classified as having active tuberculosis (Category 1) during the first 12 months following notification (Figure 2). These gradually transferred to an intermediary case-management category (Category II) and at 24 months transferred from Category II to 'clinically-cured' categories (III and VII). At 24 months, the proportion of those classified as clinically-cured was 11.3% (95% CI, 9.2 to 13.9%), thereafter increasing steadily to 42% (95% CI, 38 to 45%) at 36 months. Around 10% (95% CI, 7.8 to 12.5%) of the BK+ cases became 'chronic' cases.

Clinical cure for BK− patients was determined by chest X-ray (cavity closure) and clinical assessment. At 24 months after notification, the proportion of this group classified as clinically cured was 26.5% (95% CI, 23.8 to 29.4%), increasing at 36 months to 59.7% (95% CI, 56.8 to 62.6%). The proportion of BK− cases which remained alive at the end of 36 months and classified as chronic was 0.9% (95% CI, 0.4 to 1.8%), significantly lower than that of the BK+ cases at 8.7% (95% CI, 6.8 to 11.1%).

Health care costs

The estimated unit costs of health services for TB patients are shown in Tables 3 to 6. The mean cost per hospital

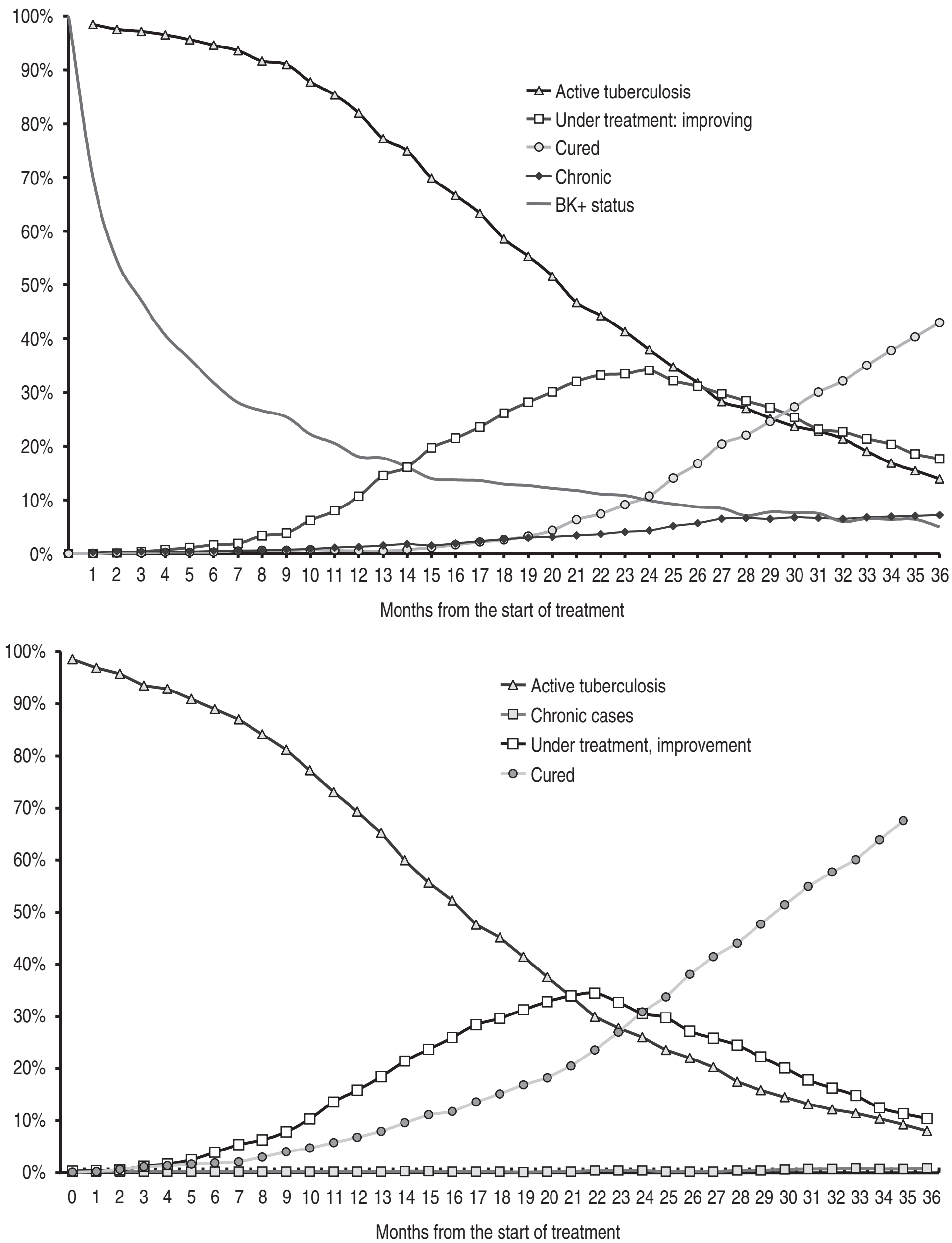


Figure 2. Outcomes for BK+ and BK− cases in the cohort (initial no. of cases: 777 and 972, respectively)

Table 2. Outcomes adjusted for censoring at 6, 12, 24 and 36 months

	Proportion of initial cohort (%) and 95% Confidence Interval[3]			
	At 6 months	At 12 months	At 24 months	At 36 months
BK+ pulmonary tuberculosis				
Conversion to smear negative	66.8 (63.4–71.9)	77.9 (73.9–81.3)	N/A[2]	N/A[2]
Chronic[1]	0.5 (0.2–1.4)	1.3 (0.9–2.9)	4.9 (4.1–7.9)	8.7 (0.069–0.113)
Cured	0.3 (0.1–1.0)	0.5 (0.2–1.4)	11.3 (9.2–13.0)	41.7 (38.2–45.2)
Deaths	1.7 (1.2–3.5)	4.3 (3.2–6.3)	10.7 (9.2–13.9)	18.2 (15.7–21.3)
BK− pulmonary tuberculosis				
Conversion to smear positive	1.5 (0.8–2.2)	1.0 (0.7–2.5)	1.4 (0.8–2.5)	N/A[2]
Chronic[1]	0.2 (0.1–0.8)	0.2 (0.1–0.8)	0.4 (0.2–1.2)	0.9 (0.5–2.2)
Cured	17.0 (10.0–27.0)	5.9 (4.6–7.7)	26.5 (23.8–29.4)	59.7 (56.8–62.6)
Deaths	1.6 (1.1–2.9)	2.4 (1.7–3.8)	5.4 (4.3–7.4)	10.0 (8.2–12.3)
Total cohort				
Chronic[1]	0.3 (0.2–0.8)	0.7 (0.5–1.5)	2.4 (0.021–0.038)	4.4 (3.6–5.7)
Cured	1.0 (0.7–1.7)	3.5 (2.7–4.5)	20.0 (18.2–22)	52.3 (50.0–54.6)
Deaths	1.6 (1.1–2.3)	3.2 (2.5–4.2)	7.8 (6.6–9.2)	13.8 (12.2–15.6)

Adjusted to loss of data using Kaplan-Meier method.
[1]The definition of chronic case is based on the Russian methodology (persistent smear-positive status or persistent chest X-ray abnormalities).
[2]Not available after 12 months for smear-positive and after 24 months for smear-negative due to the low conversion rate and the removal of smear-negative cases out of cohort.
[3]Cumulative proportion of initial cohort estimated to adjust for data censoring by the Kaplan-Meier method.

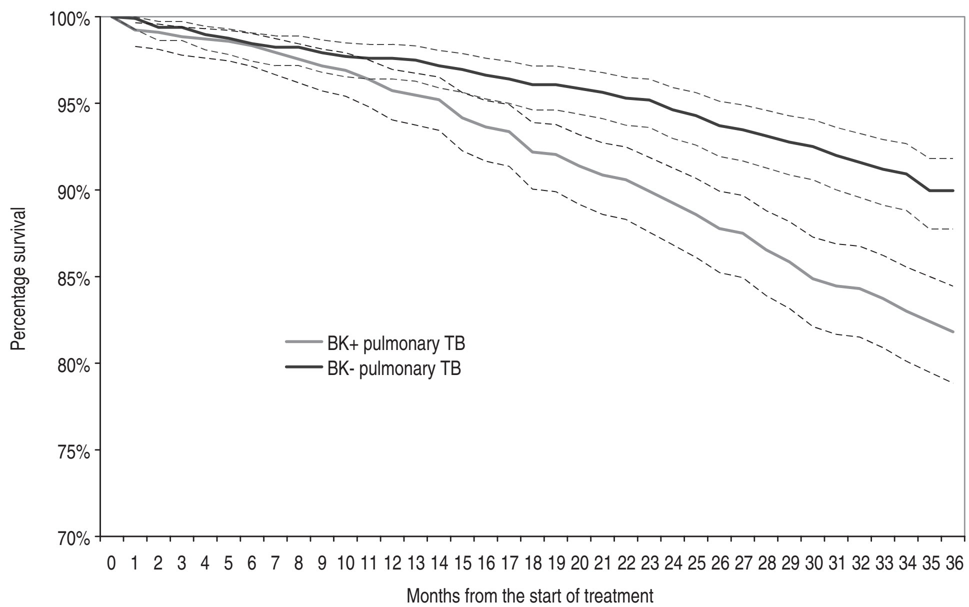


Figure 3. Three-year Kaplan-Meier survival curves (with confidence intervals) for adult patients with BK+ and BK− pulmonary tuberculosis

inpatient-day, including examinations and medication, was estimated at US$4, in line with other studies that have costed inpatient care for TB services in Russia (WHO 2002c). The cost of daily inpatient care in a surgical TB ward was estimated at US$9. The average cost per outpatient attendance and community visit was US$3.39 and US$4.6, respectively. The cost of an outpatient-based course of chemotherapy was about US$50, spread over several months.

The mean cumulative cost of treating a TB case over 3 years was estimated at US$886 (95% CI, US$853-919). Inpatient care accounted for 66% and outpatient treatment (including visits and chemotherapy) 27% of total estimated costs. A further 7% was accounted for by laboratory tests for outpatients. The cost of surgical inpatient treatment was around 13–15% of the total cost over 3 years (Table 3).

At 3 years, the mean cumulative cost of treating a BK+ case was US$1078 (95% CI, IUS$1125–1132) and US$718 (95% CI, US$680–754) for a BK− case. For BK+ cases, the cost of inpatient care accounted for 70% of the total cost of treatment over 3 years and 62% for the

Table 3. Unit costs of health services[1]

Unit of cost	Recurrent cost (US$)	Capital cost (US$)	Total cost (US$)
Hospital day: medical ward[2]	3	1.15	4.15
Hospital day: surgical ward[2]	8	1.15	9.15
Sputum microscopy test	0.69	0.10	0.79
Sputum culture test x 3	1.73	0.04	1.79
Sputum culture test with drug sensitivity	1.41	0.94	2.35
Chest X-ray on film	2.08	0.4	2.48
Chest X-ray: visual examination	0.68	0.4	1.08
Fluorography test	0.39	0.4	0.79
Outpatient chemoprophylaxis	40	0	40
Outpatient chemotherapy course	50	0	50
Outpatient appointment	2.99	0.4	3.39
Inspection community visit	4.6	0	4.6
Disinfection of house	5	0	5

[1]Figures in 1999–2000 prices and dollar exchange rate.
[2]Inpatient costs include all treatment and diagnostic services and drug costs.

Table 4. Costs of treatment per case, adjusted for censoring at 6, 12, 24 and 36 months

	Mean cumulative cost per patient in US$ (95% CI, adjusted for censoring)			
	At 6 months	At 12 months	At 24 months	At 36 months
Initially smear-positive				
Inpatient medical	346 (318–362)	456 (415–474)	550 (491–569)	614 (569–659)
Inpatient surgical	71 (48–93)	106 (79–134)	132 (99–165)	141 (105–177)
Outpatient services and chemotherapy	55 (52–58)	104 (99–109)	188 (180–196)	251 (240–261)
Lab tests and X-ray[1]	22 (21–23)	34 (33–37)	55 (53–57)	71 (68–73)
Total costs	494 (467–520)	701 (667–736)	925 (881–970)	1078 (1025–1132)
Initially smear-negative				
Inpatient medical	198 (181–215)	259 (236–281)	309 (283–335)	334 (306–363)
Inpatient surgical	59 (42–75)	78 (60–100)	98 (75–123)	107 (80–134)
Outpatient services and chemotherapy	62 (60–65)	101 (97–104)	172 (166–179)	220 (211–229)
Lab tests and X-ray[1]	17 (16–18)	28 (27–29)	43 (42–45)	56 (54–58)
Total costs	336 (314–357)	468 (440–495)	623 (590–657)	718 (680–754)
Total cohort				
Inpatient medical	259 (244–273)	341 (323–360)	409 (386–433)	455 (428–482)
Inpatient surgical	66 (52–79)	93 (76–109)	114 (94–134)	125 (103–148)
Outpatient services and chemotherapy	61 (59–63)	106 (104–109)	185 (179–190)	241 (234–249)
Lab tests and X-ray[1]	20 (19–21)	31 (30–32)	49 (48–51)	64 (63–66)
Total costs	406 (388–423)	572 (549–594)	758 (729–786)	886 (853–919)

[1]This includes only tests performed when the patient is on outpatient treatment.

BK− cases. The hospitalization level was 88% for BK+ cases and 59% for BK− cases.

For the BK+ cases, cumulative costs, incurred over the first 9 and 12 months following notification, comprised 51% (95% CI, 48.1 to 53.3%) and 60% (95% CI, 56.6 to 62.5%), respectively, of the total cumulative cost. For the BK− cases, these costs, at 9 and 12 months, were 51% (95% CI, 47.7 to 53.9%) and 59% (95% CI, 55.6 to 62.3%) of the total, respectively (Figure 4).

Discussion

Our study is the first to show in detail the costs and outcome dynamics of TB control in Russia. By reconstructing service and cost profiles for each patient in the cohort over a 3-year period, we show how outcomes and costs are spread over time. A substantial share of the overall cost (40%) is incurred after 12 months of treatment. Similarly, a substantial proportion of health outcomes (bacteriological response, cure, development of chronic disease and deaths) occur in the second and third year of treatment, because, to declare a patient as 'cured', the Russian guidelines require confirmation of both sputum conversion and closure of lung cavities on X-ray. Relatively low rates of smear conversion and the high proportion of chronic cases are of public health concern.

This study highlights the differences in clinical management, outcomes and costs for BK+ and BK− patients. In terms of outcomes, we show three differences. First, although most BK+ cases became BK− within

Table 5. Mean cumulative cost per case in US$ (95% CI, adjusted for censoring and discounted at annual rate of 3.5%)

	Mean cumulative cost per patient in US$ (95% CI, adjusted for censoring)			
	At 6 months	At 12 months	At 24 months	At 36 months
Initially smear-positive				
Inpatient medical	346 (318–362)	454 (413–472)	545 (488–565)	605 (561–649)
Inpatient surgical	71 (48–93)	105 (78–133)	131 (98–164)	139 (104–175)
Outpatient services and chemotherapy	55 (52–58)	103 (98–108)	184 (178–194)	243 (234–254)
Lab tests and X-ray[1]	22 (21–23)	34 (33–37)	54 (52–56)	69 (66–71)
Total cost	494 (467–520)	697 (664–732)	914 (874–962)	1057 (1008–1113)
Initially smear-negative				
Inpatient medical	198 (181–215)	258 (235–280)	306 (281–333)	330 (303–359)
Inpatient surgical	59 (42–75)	78 (60–100)	97 (74–122)	105 (79–132)
Outpatient services and chemotherapy	62 (60–65)	100 (96–103)	169 (164–177)	214 (206–224)
Lab tests and X-ray[1]	17 (16–18)	28 (27–29)	42 (42–45)	54 (53–57)
Total cost	336 (314–257)	466 (438–491)	615 (585–650)	704 (669–741)
Total cohort				
Inpatient medical	259 (244–273)	340 (322–359)	405 (384–430)	448 (423–476)
Inpatient surgical	66 (52–79)	93 (76–108)	113 (93–133)	123 (102–146)
Outpatient services and chemotherapy	61 (59–63)	105 (103–108)	182 (177–188)	234 (228–243)
Lab tests and X-ray[1]	20 (19–21)	31 (30–32)	48 (48–50)	62 (62–64)
Total cost	406 (388–423)	568 (546–591)	749 (723–780)	868 (839–904)

[1]This includes only tests performed when the patient is on outpatient treatment.

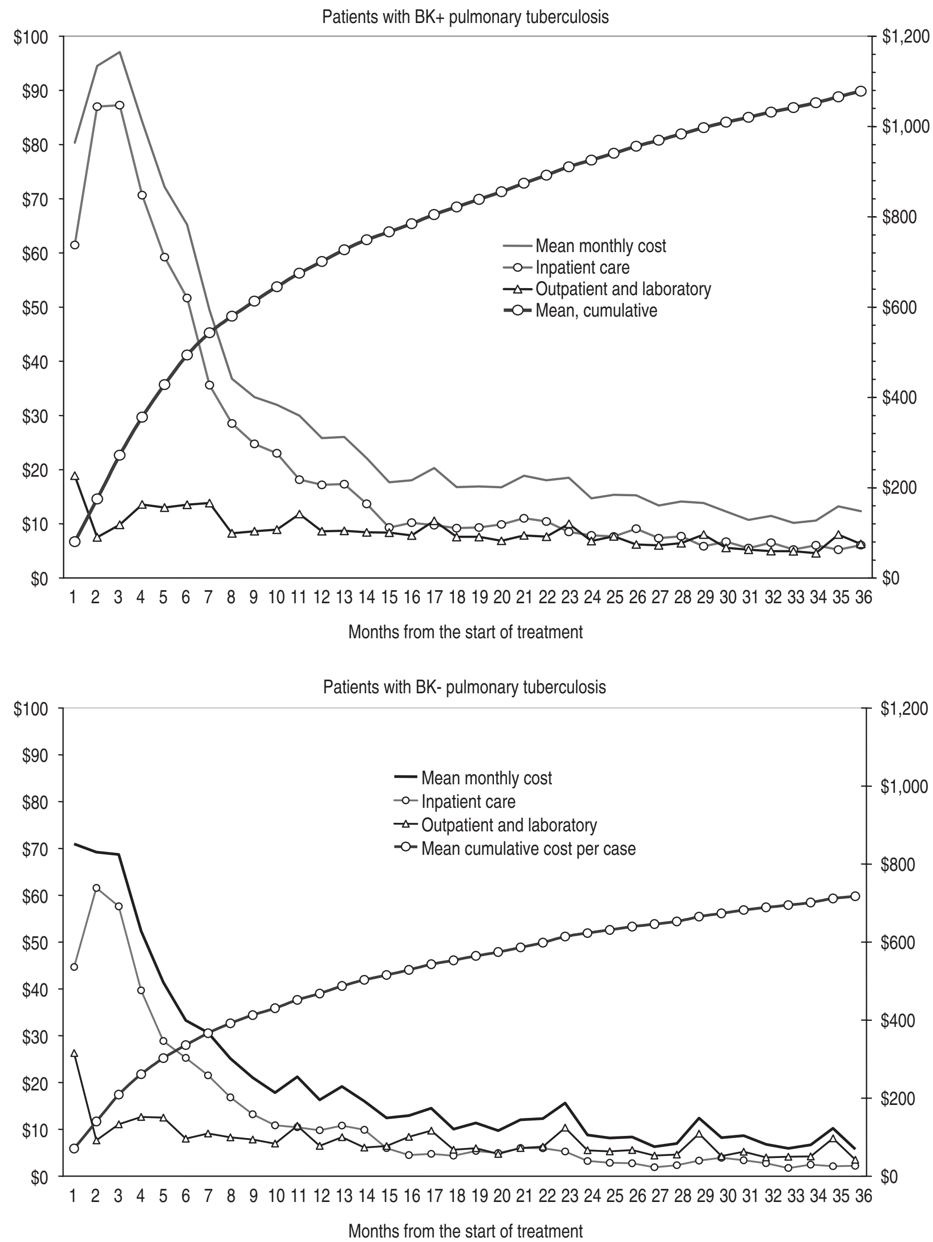
Table 6. Mean cumulative cost per case in US$ (95% CI, adjusted for censoring and discounted at annual rate of 5.0%)

	Mean cumulative cost per patient in US$ (95% CI, adjusted for censoring)			
	At 6 months	At 12 months	At 24 months	At 36 months
Initially smear-positive				
Inpatient medical	346 (318–362)	453 (413–471)	543 (487–564)	601 (558–646)
Inpatient surgical	71 (48–93)	105 (78–133)	130 (98–163)	138 (103–174)
Outpatient services and chemotherapy	55 (52–58)	103 (98–108)	183 (177–193)	240 (231–252)
Lab tests and X-ray[1]	22 (21–23)	34 (33–37)	54 (52–56)	68 (66–71)
Total cost	494 (467–520)	696 (662–731)	909 (871–959)	1048 (1002–1106)
Initially smear-negative				
Inpatient medical	198 (181–215)	258 (235–279)	305 (281–332)	328 (301–357)
Inpatient surgical	59 (42–75)	78 (60–99)	97 (74–122)	105 (79–132)
Outpatient services and chemotherapy	62 (60–65)	100 (96–103)	168 (163–176)	211 (204–222)
Lab tests and X-ray[1]	17 (16–18)	28 (27–29)	42 (41–44)	54 (52–56)
Total cost	336 (314–257)	465 (437–489)	612 (583–647)	698 (665–735)
Total cohort				
Inpatient medical	259 (244–273)	339 (321–358)	404 (383–429)	445 (421–474)
Inpatient surgical	66 (52–79)	92 (75–108)	112 (93–133)	122 (101–145)
Outpatient services and chemotherapy	61 (59–63)	105 (103–108)	180 (176–187)	231 (226–240)
Lab tests and X-ray[1]	20 (19–21)	31 (30–32)	48 (47–50)	61 (61–64)
Total cost	406 (388–423)	567 (545–590)	745 (721–777)	861 (833–898)

[1]This includes only tests performed when the patient is on outpatient treatment.

the first few months of treatment, conversion rates were still low compared with WHO targets (WHO 2004). Secondly, the rates of chronic disease and mortality were higher in BK+ cases than in BK− cases. As drug resistance is not routinely monitored and reported in Russia, we could not quantify the prevalence in our cohort. However, as part of our multi-methods study in Russia, which helped implement the WHO DOTS programme in Samara and analysed contextual and health system factors influencing adoption of the WHO DOTS strategy (Drobniewski et al. 2002; Coker et al. 2003; Atun et al. 2004; Atun et al. 2005a–e; Balabanova et al. 2005; Coker et al. 2006), we undertook analysis of drug resistance levels in TB patients. This analysis indicates the multidrug-resistant TB rates in patients recruited for DOTS treatment to be at least 4.6% in smear-positive and 1.9% in smear-negative patients, providing insights into possible reasons for this difference (Balabanova et al. 2006). Thirdly, hospitalization rates differ between groups with around 88% of BK+ cases being hospitalized compared with 60% of the BK− cases.

In terms of costs, we show that the cost of treating BK+ cases was 50% higher than treating BK− cases, the result of higher hospitalization rates for BK+



Costs are in 1999-2000 prices.
Cost profiles are adjusted to censoring using Lin (type1) method.

Figure 4. Cost of treatment per case by care sector, BK+ and BK− adult pulmonary tuberculosis

cases and the additional cost of managing BK+ cases that become 'chronic'. BK+ cases accounted for 55% of total health expenditure on TB compared with 45% for BK− cases.

In 2002, among the 22 WHO high-burden countries, Russia had the highest estimated total cost of TB programme per treated case, followed by South Africa, where TB treatment also relies on inpatient care, and Brazil (WHO 2004). These and other studies which have used cross-sectional or 1-year data have estimated costs of treating per case to be US$750 to US$1100 for bacillary-positive patients and US$520 for bacillary-negative patients (WHO 2002c). We show the average cost of care per new case of pulmonary TB to be US$571 at 12 months, increasing to US$758 at 24 months and US$886 at 36 months (US$569, US$750 and US$871 discounted at 3% at 12, 24 and 36 months, respectively, and US$567, US$745 and US$861 discounted at 5% at 12, 24 and 36 months, respectively).

Economic evaluations of TB control have typically focused on bacteriologically confirmed, or smear-positive, cases alone (Borgdorff et al. 2002), as early detection and effective treatment offer important public health benefits. However, in the Russian context, we show that bacteriologically unconfirmed cases account for a considerable proportion of the reported cases (43% of notifications) and almost half of the expenditure on TB (46% of total), and may, therefore, be important cases to include in health system and economic analyses.

Our findings suggest that long-term follow-up patterns of costs and outcomes are likely to be important for studies which compare traditional TB control with internationally approved methods. They should have a 3- to 4-year horizon rather than the more usual 1-year period used to analyse cost in internationally approved methods. Understanding the time dimension of care is essential for cost-effectiveness comparisons of Russian TB control with alternative strategies and evaluating the cost-effectiveness of a transition from traditional to new methods.

Our study was limited in a number of ways. First, we limit our analysis of costs and outcomes to 3 years. Some TB patients incur costs beyond 3 years (Atun et al. 2005a–c). Our calculations do not take into account this additional cost. Secondly, we do not include in care costs the cost of chest-X-ray case finding, which is a national screening programme managed by the Russian Federal authorities and for which we were not able to obtain data. Hence the true costs of TB are likely to be higher than the figure we have estimated. Thirdly, as in any economic evaluations, caution must be exercised with the accuracy of costs. To mitigate this we triangulated our cost data with other sources and sought the opinion of local economists and health professionals. To enhance the accuracy of our study, we included in our analysis the 69% of cases in the cohort which had complete cost and outcome data and excluded from the study those which did not. This may introduce bias to the study as those with incomplete data may be those who have left the system or have interrupted treatment, and those who are classified as being chronic cases and hence stay longer in the system with a higher chance of having incomplete data. Collectively, these biases may lead to a higher cost of management as these cases are more difficult and costly to manage. Fourthly, our study was in one region. However, studies of TB control in Russia have identified consistency in case management, costs and average length of hospital admission across regions, as well as in the important social support function of Russia's TB hospitals, and identified Samara as a 'typical' region (Coker et al. 2003; Atun et al. 2005b; Floyd et al. 2006). This consistency suggests that our results are likely to hold in the rest of the country's 88 regions.

Conclusions and policy implications

Our findings have policy implications for Russia and other post-Soviet countries where TB control systems similar to that in Russia exist – characterized by lengthy case management and frequent hospitalization, driven by regulations on clinical case management, financing and organizational arrangements.

Russia has not been able to achieve the WHO targets for TB control. Despite significant investments, from local and international sources, Russia has one of the lowest coverage levels for DOTS amongst the 22 high-burden countries (Kherosheva et al. 2003; Elzinga et al. 2004) and a disproportionately high cost of managing TB cases.

The rationale for implementing the DOTS strategy in Russia, as in other post-Soviet countries, is to establish cost-effective TB control by reducing unnecessary care costs due to lengthy hospitalizations, while improving cure rates and reducing the development of drug resistant TB. The WHO DOTS strategy, employing a standardized treatment for 6 months, produces the highest cure rates for drug-sensitive TB, while the Russian TB service, which traditionally employed individualized treatment, has poorer outcomes as compared with DOTS treatment. Evidence from other countries does suggest that outpatient care for TB patients is feasible and of lower cost than inpatient care (Floyd et al. 1997, 2003; Nganda et al. 2003; Okello et al. 2003). Hence, successful implementation of the DOTS strategy may help to improve the efficiency and effectiveness of TB care in Russia.

In Russia and other post-Soviet countries, TB hospitals shoulder the costs of extensive periods of clinical care and the substantial burden of important and necessary non-clinical social support for vulnerable populations (Atun et al. 2005a,b). In these systems, improving the efficiency with which existing resources are used will require reform of health system norms and regulations related to planning, financing and clinical care, and improving linkages between health and social sectors (Atun et al. 2005a; Floyd et al. 2006). For example, until recently, Russian regulations on TB control stipulated a target of hospitalizing 95–98% of the new cases of pulmonary TB but made little distinction between individuals who are infectious (and therefore pose a substantial public health challenge) and those who are not (Ministry of Health 2003). Adoption of recent Ministerial Decrees on TB control signal a shift in policy towards internationally accepted methods of TB control (Ministry of Health 2003, 2004).

Changes in guidelines, incentive structures and financing rules in health services are needed to enable implementation and sustainable development of cost-effective community-based TB services, whilst retaining an appropriate hospital infrastructure to provide for those cases which need to be hospitalized. Hence, in Russia, national and international agencies supporting TB control need to focus on medium- to long-term improvements in the health system, not just short-term changes to methods for clinical management of TB.

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