# Predictors of treatment failure among tuberculosis patients under DOTS strategy in Egypt

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## المنبئات بإخفاق استراتيجية المعالجة القصيرة الأمد تحت الإشراف المباشر في مصر

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**الخلاصة:** يُعَدُّ إخفاق المعالجة أحد المشكلات الخطيرة التي تواجه بعض البرامج الوطنية لمكافحة السل، وقد تمثّل عبئاً اقتصادياً وتطيل الفترة التي يظل فيها المريض مُعْدياً. ويُعَدُّ عدم انتظام المعالجة من العوامل التي قد تؤدي إلى إخفاق المعالجة. وقد أجريت دراسة للحالات والشواهد في مراكز مكافحة السل في جميع المحافظات المصرية خلال الفترة من نيسان/أبريل 2001 إلى كانون الأول/ديسمبر 2002 لاستقصاء المنبئات بإخفاق المعالجة بين مرضى السل الذين يتلقّون المعالجة القصيرة الأمد تحت الإشراف المباشر. وقد أُجريت مقابلة 119 ممن أخفقت معالجتهم (الحالات) وعدد مماثل من الحالات التي شفيت من السل (الشواهد)، كما أُجريت مقابلة أفراد عائلاتهم للاستفسار عن الخصائص الاجتماعية والديمغرافية لكل مريض وأسرته مع معلومات عن المرض وعن معلومات الأدوية المأخوذة والامتثال للمعالجة، والدعم الذي تقدِّمه الأسرة والتفاعل المتبادل بين المرضى وأسرهم. وقد كان أهم عوامل احتمال إخفاق المعالجة متمثّلاً في عدم الامتثال للمعالجة، ونقص التثقيف الصحي للمرضى وقلة معارفهم حول المرض، والإصابة بالسكَّري كمرض مرافق.

ABSTRACT Treatment failure is a serious problem facing some national tuberculosis (TB) control programmes. Irregularity of treatment is a factor that can lead to treatment failure. A case–control study was carried out in TB centres in Egypt during April 2001–December 2002 aimed at investigating the predictors of treatment failure. We interviewed 119 people with treatment failure and an equal number of cured cases (controls) and their families regarding sociodemographic characteristics, information about TB, information about drugs, treatment compliance, family support and patient–family interaction. Significant risk factors for treatment failure were non-compliance to treatment, deficient health education to the patient, poor patient knowledge regarding the disease and diabetes mellitus as co-morbid condition.

**Facteurs prédictifs de l'échec du traitement chez les tuberculeux sous traitement DOTS en Egypte**
RESUME L'échec du traitement est un grave problème auquel sont confrontés certains programmes nationaux de lutte antituberculeuse. L'irrégularité du traitement est un facteur qui peut entraîner son échec. Une étude cas-témoins a été réalisée en Egypte dans les centres de traitement de la tuberculose entre avril 2001 et décembre 2002 afin de déterminer les facteurs prédictifs de l'échec du traitement. Nous avons interrogé 119 personnes dont le traitement avait échoué et le même nombre de personnes ayant été guéries (témoins) ainsi que leur familles sur les points suivants : caractéristiques socio-démographiques, information sur la tuberculose, information sur les médicaments, observance du traitement, soutien familial et interaction patient-famille. Les facteur de risque importants pour l'échec du traitement étaient la non-observance du traitement, l'insuffisance de l'éducation sanitaire du patient, une mauvaise connaissance par le patient de sa maladie et du diabète sucré comme pathologie comorbide.

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## Introduction

Cure rate is a good indicator of the success of any national programme for tuberculosis (TB) control. Treatment failure is a health and economic burden as the patient remains a source of infection in the community and it may lead to the development of multidrug resistance, apart from the indirect economic burden attributed to absence from work and inability to work.

Egypt has succeeded in implementing the directly observed treatment, short course (DOTS) strategy nationwide. This strategy involves the direct observation of patients during drug intake to ensure that the full treatment course is followed. It has been shown that patients treated without direct observation have a substantially higher risk of adverse outcome than those treated under direct observation [*1*].

The national TB control programme in Egypt was launched in 1989 in Cairo and Giza, then expanded to cover the whole country by the year 1999. The DOTS strategy started on a pilot basis in 1996 and was then extended to reach 100% coverage in December 2000 [*2*]. The strategy entails regular daily observation of the treatment in the first 2 months in the initial phase. This is followed by weekly observation in which the patient visits the treating health centre once a week where he/she takes the medicine for that day and is given medicines for the rest of the week. Each patient should pay 76 visits to the centre during the whole treatment period. The treatment regimen is 2 S(E)HRZ/4 HR (2 months intensive phase streptomycin or ethambutol, isoniazid, rifampicin and pyrazinamide; 4 months maintenance phase isoniazid and rifampicin) [*3*] as recommended in the national TB control guidelines.

Treatment failure is a serious problem for TB control programmes in many countries throughout the world. Cases tend to have higher mortality and remain infectious for prolonged periods of time, hence are capable of transmitting the disease to other members of the community. In Egypt, treatment failure accounts for 3%–5% of the treatment outcome of new smear-positive cases and 13%–17% of re-treated cases [*4*].

Patients identified with treatment failure have more localized disease as shown on chest radiographs, less radiographic improvement at follow-up, higher prevalence of drug resistance, and are less compliant with medication [*5*]. Treatment failure may be due to poor compliance of the patient or to practitioner error, e.g. in cases where inadequate regimens and/or shortened periods of treatment are prescribed [*6*]. One of the most important causes of unsuccessful treatment is irregularity and loss to follow-up, which may be due to patients being transferred to another unit [*7*]. Many patients stop treatment as soon as they feel better [*8*]. Such patients are in need of an intensive programme of health education [*9*]. A report from the United States of America showed that non-compliance was associated with a 10-fold increase in the occurrence of poor treatment outcomes and accounted for most treatment failures. The study recommended innovative programmes to deal with addiction and homelessness as these were identified as the main causes of non-compliance in the community studied [*10*]. Another study from the USA reported that non-adherence to treatment was strongly associated with lifestyle, family circumstances, family support, motivation and education [*11*].

Treatment failure may also be due to low serum antimicrobial drug levels, which can be identified by checking serum drug levels in patients [*12*]. In addition, treatment failure can be attributed to multidrug-resistant TB. The extent of antituberculosis

drug resistance varies greatly between countries. In one study in South Africa the rates of primary and acquired drug resistance were 7.3% and 14.3% respectively for isoniazid and 1% and 2.8% for resistance to at least isoniazid and rifampicin (multidrug resistance) [*13*].

Our study was undertaken in order to investigate the predictors of treatment failure among new smear-positive TB cases under DOTS in Egypt, with special emphasis on treatment compliance.

## Methods

### Subjects and setting

A matched case–control study was conducted in all TB centres of all the governorates in Egypt that reported cases of treatment failure during the period April 2001–December 2002. Cases and controls were frequency matched by sex and TB centre, i.e. sex and TB centre distribution was the same for both cases and controls.

The input criteria for sample size estimation were: assuming a rate of non-compliance of 20% among treatment failure cases and 5% among cured cases, at 95% confidence interval, 80% study power, and a ratio of 1:1 for cases and controls. The estimated sample size was 88 in each group. Owing to the large number of variables studied and the expected number of drop-outs, however, the sample size was increased to 119 for cases and controls (total sample size 238 TB patients).

New smear-positive patients who were declared as treatment failure (as treatment outcome) at the end of their treatment were enrolled in the study and labelled as study cases. The control group consisted of patients who were declared cured at the end of their treatment. Patients were enrolled until the sample size for each group was completed. All cases and controls gave their consent to participate in the study (response rate 100%).

### Definitions

- New case: patient with TB who was never treated with anti-tuberculosis medications before or treated for a period of less than 1 month. [*11*]
- Treatment failure: patient while on treatment remains smear-positive or reverts to testing smear-positive 5 months or more after commencing treatment. This includes patients who were initially smear-negative before starting treatment and became smear-positive after the second month of treatment. [*11*]
- Cured: patients smear-negative at or one month prior to the completion of treatment and on at least one previous occasion. [*11*]
- Concomitant conditions: include diabetes, immunosuppressive disease, malabsorption syndrome, walking disability, HIV/AIDS, chronic obstructive pulmonary disease. The concomitant diseases/conditions that might influence treatment outcome were listed during the interview but diabetes mellitus and walking disability were the only conditions found either by interview or by cross checking the medical records. Other medical conditions unrelated to TB, such as fracture and heart disease, were categorized as "unrelated conditions."

### Data collection and analysis

Cases and controls, along with one family member for each, were interviewed using a pre-tested and structured questionnaire to collect information regarding the potential predictors of treatment failure such as sociodemographic factors, treatment compliance, knowledge regarding the disease,

degree of health education delivered, satisfaction with care and accessibility of TB centres.

The questionnaire was tested for content validity to determine if it still measured what it was intended to test. To examine the internal consistency of the items of the questionnaire, Cronbach's alpha was calculated. Interrater and intrarater reliability of the questionnaire were also estimated.

Items used for assessing satisfaction with care were: privacy in the examination room, privacy in the X-ray examination, how the doctors deal with patients, how nurses deal with patients, how the social workers deal with patients, waiting time for investigation and waiting time to receive treatment. A summation score for satisfaction with care was then generated by adding the total scores obtained.

Items used for assessing family knowledge were: family knowledge about the diagnosis, duration of treatment, drugs taken and the disease. A summation score for family knowledge about TB was generated by adding the total scores obtained.

Patients' knowledge about the disease was rated as adequate if judged good or very good by the interviewer. It was rated inadequate if judged very poor, poor, or moderate by the interviewer.

Patient interviews were carried out by health workers in the TB centres which reported cases of treatment failure. The interviewers had no knowledge of treatment outcomes.

Simple descriptive statistics were calculated. Cases and controls were frequency-matched by sex and TB centre rather than matching each case to each control. Therefore, matching was broken down in the analysis and standard analysis was used instead of the analysis recommended for matched case–control studies (McNemar test and conditional logistic regression) [*14*]. The chi-squared test was used for comparison of proportions. Univariate and standard (unconditional) logistic regression analyses were performed in order to study the predictors of treatment failure by calculating crude and adjusted odds ratios and their 95% confidence intervals. The statistical packages used were *Epi-Info* (version 6.04d) and *SPSS* (version 10).

## Results

Table 1 shows the distribution of patients with treatment failure as outcome at the end of treatment in 17 Egyptian governorates. Treatment failure rates ranged from 0.9%–5.1%, being highest in Assiut, Gharbia, Cairo, and Quena, and lowest in Fayoum, Ismailia, and Port Said.

There was no significant difference between cases and controls regarding sociodemographic characteristics (Table 2). The factors affecting accessibility to health services are presented in Table 3. Those with treatment failure lived significantly farther from TB centres, 26.9% ≥ 10 km compared to 10.9% of controls, and reported a significantly higher frequency of diabetes mellitus as co-morbid condition (26.1%) compared to the control group (7.8%).

Table 4 shows that there is a statistically significant difference between cases and controls regarding their degree of knowledge about TB as well as their source of information and degree and timing of health education delivered. The most important sources of information for patients were the media and the chest hospital. Non-attendance at any health education session was reported by 12.0% of cases compared to only 1.7% of controls.

Table 5 shows that privacy was ensured during medical and X-ray examination.

Table 1 **Distribution of 119 patients with treatment failure outcome in 17 Egyptian governorates, April 2001–December 2002**

| Governorate | No. of cases with treatment failure enrolled | No. of cases | Rate of treatment failure (%) |
|---|---|---|---|
| Assuit | 15 | 294 | 5.1 |
| Gharbia | 13 | 289 | 4.5 |
| Cairo | 16 | 621 | 2.6 |
| Qena | 7 | 279 | 2.5 |
| Qalubia | 8 | 363 | 2.2 |
| Daqahlia | 8 | 385 | 2.1 |
| Minya | 6 | 293 | 2.1 |
| Alexandria | 9 | 448 | 2.0 |
| Sharqia | 7 | 354 | 2.0 |
| Sohag | 9 | 490 | 1.8 |
| Kafr Al Sheikh | 5 | 273 | 1.8 |
| Beni Suef | 3 | 171 | 1.8 |
| Giza | 8 | 515 | 1.6 |
| Suez | 1 | 65 | 1.5 |
| Port Said | 1 | 70 | 1.4 |
| Ismailia | 1 | 96 | 1.0 |
| Fayoum | 2 | 223 | 0.9 |
| Total | 119 | | |

P > *0.05.*

There was no significant difference between cases and controls regarding satisfaction with care delivered by nurses and social workers. On the other hand, cases were less satisfied than controls about the care delivered by physicians and the time they had to wait to receive their treatment (72.2% versus 84.0%, respectively).

Families of cured patients (controls) reported significantly better knowledge regarding diagnosis, treatment duration and drugs given compared to cases. Patients with treatment failure as outcome (cases) had a significantly bigger family size and a greater number of children compared to controls (Table 6).

Multivariate logistic regression analysis was performed to study the determinants of treatment failure (Table 7). The following independent variables, found to be significant by chi-squared test, were introduced in the model: distance to the TB centre, presence of other disease, health education, satisfaction with care, family size, household members < 15 years, patient's knowledge regarding the disease, family knowledge regarding the disease and number of missed doses. Age and sex were

Table 2 **Sociodemographic characteristics of the new smear-positive patients enrolled in the study**

| Variable | Cases *N* = 119 No. | % | Controls *N* = 119 No. | % | Chi-squared | *P*-value | Crude OR (95% CI) |
|---|---|---|---|---|---|---|---|
| *Age group* | | | | | | | |
| < 25 | 18 | 15.1 | 23 | 19.3 | 2.29 | 0.515 | 1 |
| 25–44 | 67 | 56.3 | 62 | 52.1 | | | 1.38 (0.64–2.97) |
| 45–54 | 16 | 13.5 | 21 | 17.7 | | | 0.97 (0.36–2.63) |
| ≥ 55 | 18 | 15.1 | 13 | 10.9 | | | 1.77 (0.62–5.08) |
| *Education* | | | | | | | |
| Illiterate | 71 | 59.7 | 71 | 59.7 | 0.19 | 0.980 | 1 |
| Read and write | 25 | 21.0 | 27 | 22.7 | | | 0.93 (0.47–1.83) |
| Primary and preparatory | 7 | 5.9 | 6 | 5.0 | | | 1.17 (0.33–4.16) |
| Secondary and university | 16 | 13.5 | 15 | 12.6 | | | 1.07 (0.46–2.49) |
| *Marital status* | | | | | | | |
| Married | 69 | 58.0 | 80 | 67.2 | 2.23 | 0.327 | 1 |
| Single | 36 | 30.3 | 29 | 24.4 | | | 1.44 (0.77–2.70) |
| Widowed and divorced | 14 | 11.8 | 10 | 8.4 | | | 1.62 (0.63–4.24) |
| *Occupation*[a] | | | | | | | |
| Manual work | 31 | 27.9 | 36 | 30.5 | 0.53 | 0.768 | 1 |
| Office work | 22 | 19.8 | 26 | 22.0 | | | 0.98 (0.44–2.21) |
| Not working | 58 | 52.3 | 56 | 47.5 | | | 1.20 (0.63–2.30) |
| *Sex* | | | | | | | |
| Male | 79 | 64.4 | 79 | 64.4 | – | – | 1 |
| Female | 40 | 33.6 | 40 | 33.6 | | | 1 (0.56–1.77) |

[a]*Data missing: 8 cases and 1 control excluded.*
*OR = odds ratio.*
*CI = confidence interval.*

introduced to adjust for their confounding effect.

The statistically significant risk factors for treatment failure were:

- diabetes mellitus as co-morbid condition (more than 9-fold increased risk for treatment failure)
- deficient health education sessions to the patient (more than 11-fold increased risk for treatment failure)
- poor patient knowledge regarding the disease (almost 5-fold increased risk for treatment failure)
- missed doses of antituberculosis drugs (1.4-fold increased risk for each dose missed).

The number of missed doses was then categorized in order to test the cut-off value which would significantly affect treatment outcome. It was found that 8 missed doses are associated with an increase in the risk of treatment failure and this was statistically significant (OR: 3.4, 95% CI: 1.41–8.05).

Forty seven cases with treatment failure as outcome were compliant to treatment

Table 3 **Comparison between cases and controls regarding the factors affecting accessibility to health services**

| Variable | Cases *N* = 119 No. | % | Controls *N* = 119 No. | % | Chi-squared | *P*-value | Crude OR (95% CI) |
|---|---|---|---|---|---|---|---|
| *Time needed to reach clinic (minutes)* | | | | | | | |
| < 15 | 49 | 41.2 | 54 | 45.4 | 1.22 | 0.544 | 1 |
| 15–35 | 40 | 33.6 | 42 | 35.3 | | | 1.05 (0.56–1.96) |
| > 35 | 30 | 25.2 | 23 | 19.3 | | | 1.44 (0.70–2.96) |
| *Distance to clinic (km)* | | | | | | | |
| < 3 | 45 | 37.3 | 50 | 42 | 10.29 | 0.006 | 1 |
| 3–9 | 42 | 36.8 | 56 | 47.1 | | | 0.83 (0.45–1.53) |
| ≥ 10 | 32 | 26.9 | 13 | 10.9 | | | 2.74 (1.2–6.29) |
| *Concomitant disease*[a] | | | | | | | |
| No other diseases | 74 | 62.2 | 84 | 73.0 | 14.45 | 0.001 | 1 |
| Diabetes | 31 | 26.1 | 9 | 7.8 | | | 3.91 (1.65–9.5) |
| Walking disability | 14 | 11.8 | 22 | 19.1 | | | 0.72 (0.32–1.60) |

[a]*Unknown status was 3.4% for controls due to missing data for 4 controls.*
*OR = odds ratio.*
*CI = confidence interval.*

(39.5% of cases). In order to study the determinants of treatment failure among this group, a second model was developed. The statistically significant predictors of treatment failure in spite of compliance were: male sex, household members < 15 years, diabetes mellitus as co-morbid condition (more than 10-fold increased risk for treatment failure) and poor patient knowledge regarding the disease (almost 10-fold increased risk for treatment failure) (Table 8).

## Discussion

The predictors of treatment failure reported in this study were: non-compliance to treatment, deficient patient knowledge/health education and diabetes mellitus co-morbidity. These factors together explained two thirds of the cases of treatment failure. Possible factors in the remaining proportion could be drug resistance or drug quality, which were not investigated in our study.

Non-compliance is a behavioural problem, the determinants of which vary from one context to another. It has always been associated with the emergence of multidrug-resistant TB and poor treatment outcome [*15,16*]. In a study in Nigeria, the only factor that significantly influenced the rate of compliance was proximity to the chest clinic [*15*]. This was not evident in our study, probably due to the decentralization of TB services in primary health care centres throughout the country. On the other hand, in agreement with our results, the extent of health education and patient knowledge regarding the disease have been shown to be significant determinants of adherence to treatment, and consequently, of treatment failure. [*17*]

Table 4 **Comparison between cases and controls regarding knowledge about TB**

| Variable | Cases *N* = 119 No. | % | Controls *N* = 119 No. | % | Chi-squared | *P*-value | Crude OR (95% CI) |
|---|---|---|---|---|---|---|---|
| *Patient information about TB* | | | | | | | |
| Adequate | 46 | 38.7 | 92 | 77.3 | 36.49 | < 0.001 | 1 |
| Inadequate | 73 | 61.3 | 27 | 22.7 | | | 5.41 (2.96–9.93) |
| *Source of information*[a] | | | | | | | |
| TV | 8 | 7.5 | 21 | 18.9 | 18.27 | 0.006 | – |
| Chest hospital | 13 | 12.3 | 13 | 11.7 | | | – |
| Family | 6 | 5.7 | 8 | 7.2 | | | – |
| Private doctor | 1 | 0.9 | 5 | 4.5 | | | – |
| Old patient | 11 | 10.4 | 4 | 3.6 | | | – |
| TV and hospital | 13 | 12.3 | 3 | 2.7 | | | – |
| Can't decide | 54 | 50.9 | 57 | 51.4 | | | – |
| *Health education*[b] | | | | | | | |
| Before and during treatment | 59 | 49.6 | 62 | 53.0 | 9.62 | 0.022 | 1 |
| During treatment | 22 | 18.5 | 24 | 20.5 | | | 0.96 (0.46–2.01) |
| At the start of treatment | 24 | 20.2 | 29 | 24.8 | | | 0.87 (0.43–1.75) |
| No health education | 14 | 11.8 | 2 | 1.7 | | | 7.36 (1.49–49.07) |
| *Number of health education sessions*[c] | | | | | | | |
| High | 37 | 31.6 | 41 | 34.5 | 12.00 | 0.007 | 1 |
| Moderate | 20 | 17.1 | 32 | 26.9 | | | 0.69 (0.32–1.5) |
| Low | 46 | 39.3 | 44 | 37.0 | | | 1.16 (0.60–2.23) |
| None | 14 | 12.0 | 2 | 1.7 | | | 7.76 (1.52–53.12) |

[a]*Data missing: 13 cases and 8 controls excluded.*
[b]*Data missing: 2 controls excluded.*
[c]*Data missing: 2 cases excluded.*
*OR = odds ratio.*
*CI = confidence interval.*
P < *0.05 was considered significant.*

Some reports have shown an association between adherence to treatment and family composition [*18,19*]. In fact, the presence of children in the family was protective against treatment failure in our study, although the results were not statistically significant. This might be due to the feeling of responsibility parents have, which urges them to seek proper care and adhere to treatment. Adolescents in the family may also confer a sort of supervision on their parents.

An alarming finding in our study was that 39.5% of those who had treatment failure as outcome were compliant to treatment. Investigating the predictors of treatment failure among this compliant group suggests that treatment outcome could be negatively influenced by male sex and increasing age as 2 biological factors. Patient knowledge and diabetes mellitus were also consistent predictors of treatment failure in this group.

Table 5 **Comparison between cases and controls regarding their satisfaction with care delivered in health facilities**

| Variable | Cases | | Controls | | Chi-squared | *P*-value |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | | |
| *Privacy in examination room* | | | | | | |
| Yes | 111 | 93.3 | 111 | 93.3 | 0.0 | 1 |
| No | 8 | 6.7 | 8 | 6.7 | | |
| *Privacy in x-ray examination room* | | | | | | |
| Yes | 110 | 92.4 | 105 | 88.2 | 1.20 | 0.273 |
| No | 9 | 7.6 | 14 | 11.8 | | |
| *How doctor deals with patient* | | | | | | |
| Very good | 86 | 72.2 | 100 | 84.0 | NV | NV |
| Good | 31 | 26.1 | 19 | 16.0 | | |
| Bad | 2 | 1.7 | – | – | | |
| *How nurse deals with patient* | | | | | | |
| Very good | 88 | 73.9 | 96 | 80.7 | NV | NV |
| Good | 29 | 24.4 | 23 | 19.3 | | |
| Bad | 2 | 1.7 | – | – | | |
| *How social worker deals with patient* | | | | | | |
| Very good | 74 | 62.2 | 86 | 72.3 | NV | NV |
| Good | 41 | 34.5 | 33 | 27.7 | | |
| Bad | 4 | 3.3 | – | – | | |
| *Waiting time for investigation* | | | | | | |
| ≤ 30 minutes | 29 | 24.4 | 30 | 25.2 | 0.07 | 0.967 |
| 31–60 minutes | 32 | 26.9 | 33 | 27.7 | | |
| > 60 minutes | 58 | 48.7 | 56 | 47.1 | | |
| *Waiting time to receive treatment* | | | | | | |
| ≤ 15 minutes | 35 | 49.4 | 47 | 39.5 | 9.78 | 0.008 |
| 16–30 minutes | 57 | 27.9 | 62 | 52.1 | | |
| > 30 minutes | 27 | 22.7 | 10 | 8.4 | | |
| *Satisfaction with care summation score*[a, b] | | | | | | |
| Adequate | 68 | 57.1 | 91 | 76.5 | 10.02 | 0.002 |
| Inadequate | 51 | 42.9 | 28 | 23.5 | | |

*NV = chi-squared non-valid.*
[a]*Median cut-off value.*
[b]*Odds ratio: 2.44; 95% CI: 1.40–4.26.*
P < *0.05 was considered significant.*

Table 6 **Comparison between cases and controls regarding family size and knowledge about tuberculosis treatment**

| Variable | Cases | | Controls | | Chi-squared | *P*-value |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | | |
| *Family size* | *N* = 119 | | *N* = 119 | | | |
| < 3 | 39 | 32.8 | 15 | 12.6 | 13.80 | 0.001 |
| 3–5 members | 61 | 51.3 | 79 | 66.4 | | |
| ≥ 6 | 19 | 15.9 | 25 | 21.0 | | |
| *Family knowledge about the diagnosis* | *n* = 106 | | *n* = 113 | | | |
| Family knows | 64 | 60.4 | 94 | 83.2 | 14.16 | < 0.001 |
| Family doesn't know | 42 | 39.6 | 19 | 16.8 | | |
| *Family knowledge about the duration of treatment* | *n* = 99 | | *n* = 109 | | | |
| Family knows | 48 | 48.5 | 68 | 62.4 | 4.06 | 0.044 |
| Family doesn't know | 51 | 51.5 | 41 | 37.6 | | |
| *Family knowledge about drugs taken* | *n* = 110 | | *n* = 114 | | | |
| Family knows | 61 | 55.5 | 78 | 68.4 | 4.06 | 0.046 |
| Family doesn't know | 49 | 44.5 | 36 | 31.6 | | |
| *Family knowledge about the disease* | *n* = 110 | | *n* = 113 | | | |
| Family knows | 81 | 73.6 | 91 | 80.5 | 1.50 | 0.220 |
| Family doesn't know | 29 | 26.4 | 22 | 19.5 | | |
| [a]*Family knowledge summation score* | *n* = 93 | | *n* = 109 | | | |
| Adequate | 53 | 57.0 | 75 | 71.4 | 4.50 | 0.030 |
| Inadequate | 40 | 43.0 | 30 | 28.6 | | |
| | **Mean** | ***s*** | **Mean** | ***s*** | | |
| *Family size* | | | | | | |
| Total No. in family | 4.18 | 1.76 | 3.40 | 2.05 | [b]Z = –3.07 | 0.002 |
| No. of household members < 15 years | 1.31 | 1.25 | 0.98 | 1.30 | [b]Z = –2.32 | 0.020 |

[a]*OR: 1.89; 95% CI: 1.05–3.40.*
[b]*Mann–Whitney test.*
s = *standard deviation.*
P < *0.05 was considered significant.*

Diabetes mellitus appears to have both an induction and aggravating effect on TB. Tuberculosis is more frequent in diabetics than non-diabetics. Radiological signs of the disease are more pronounced in diabetics. Treatment failure and death are also more frequent. Tuberculosis aggravates diabetes and increases the frequency of complications compared to diabetics without TB [*20,21*].

Our study showed that missing at least 8 days of treatment during the whole treat-

Table 7 **Predictors of treatment failure among new tuberculosis cases**

| Determinants of treatment failure | Adjusted OR (95% CI) |
|---|---|
| Age | 0.97 (0.93–1.00) |
| Family's knowledge regarding the disease (summation score) | 1.36 (0.96–1.94) |
| Missed doses | 1.40 (1.24–1.58)* |
| Family size | 0.97 (0.73–1.28) |
| Distance to the TB centre | 1.07 (0.97–1.18) |
| Walking disability | 0.25 (0.05–1.21) |
| Satisfaction with care summation score | 1.10 (0.84–1.44) |
| Number of household members <15 years old | 0.71 (0.48–1.05) |
| *Presence of other disease* | |
| No[b] | 1 |
| Diabetes | 9.32 (2.7–31.69)* |
| *Health education*[a] | |
| Before and during treatment[b] | 1 |
| During treatment | 1.21 (0.35–4.16) |
| At start of treatment | 0.58 (0.18–1.92) |
| None | 11.76 (1.32–105.17)* |
| *Sex* | |
| Male[b] | 1 |
| Female | 0.51 (0.19–1.37) |
| *Patient's knowledge regarding the disease* | |
| Adequate[b] | 1 |
| Inadequate | 4.87 (1.89–12.52)* |

[a]*The source of information could not be considered a determinant of treatment failure, and therefore, was not included in the model.*
[b]*Reference category.*
**P < 0.05.*
*These variables explained 60.6% of the variability in treatment failure (Nagelkerke R2 = 60.6%).*
*OR = odds ratio.*
*CI = confidence interval.*

Table 8 **Predictors of treatment failure among new TB cases who were compliant to treatment**

| Determinants of treatment failure | Adjusted OR | 95% CI |
|---|---|---|
| Age | 0.99 | 0.96–1.03 |
| Distance to the TB centre | 1.01 | 0.90–1.13 |
| Satisfaction with care summation score | 1.23 | 0.94–1.61 |
| Number of household members < 15 years | 0.62 | 0.39–0.97* |
| Family size | 1.05 | 0.76–1.45 |
| *Sex* | | |
| Male[a] | 1 | – |
| Female | 0.31 | 0.10–0.99* |
| *Presence of other disease* | | |
| No[a] | 1 | – |
| Diabetes | 10.08 | 2.46–41.29* |
| Walking disability | 0.51 | 0.11–2.39 |
| *Patient's knowledge regarding the disease* | | |
| Adequate[a] | 1 | – |
| Inadequate | 9.84 | 3.27–29.58* |

[a]*Reference category.*
**P < 0.05.*
*These variables explained 46.1% of the variability in treatment failure.*
*OR = odds ratio.*
*CI = confidence interval.*

ment period would significantly affect treatment outcome, indicating the need to strengthen supervision throughout the treatment period.

Poor patient knowledge regarding TB proved to be a significant predictor of treatment failure, thereby uncovering a deficiency in the health education delivered to patients. Strengthening health education in DOTS strategy is therefore recommended.

Diabetic patients proved to be at significantly higher risk of treatment failure and should be subject to tight blood sugar control and supervision. These results suggest proper glycaemic control such as that rec-

ommended by the American Diabetes Association for the management of concurrent infection in diabetic patients [*22*] would be worthwhile. This might entail shifting from oral antidiabetic drugs to insulin for TB patients until completion of treatment.

Our results emphasize the need for strengthening supervision of treatment compliance, proper control of diabetes, ensuring proper health education and timely and high quality care to all patients.

## Acknowledgement

This investigation received technical and financial support from the joint WHO Eastern Mediterranean Region (EMRO), Division of Communicable Diseases (DCD) and the WHO Special Programme for Research and Training in Tropical Diseases (TDR): the EMRO/DCD/TDR Small Grants Scheme for Operational Research in Tropical and Communicable Diseases.

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