

Capture - Recapture based Study on The Completeness of Smear Positive Pulmonary Tuberculosis Reporting in southwest Iran during 2016

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Abstract

Background

Tuberculosis (TB) is one of the ten leading causes of death in infectious diseases and one of the ten leading causes of death in the world. For any TB control program, a reliable surveillance is essential. In order to assess the status of the Surveillance, the quality of the record and the completeness of reporting should be assessed. The purpose of this study was to investigate the completeness of smear positive pulmonary tuberculosis reporting in Ahvaz of Iran.

Methods

The study was conducted through a Three-source Capture recapture method by collecting laboratory, hospital, and physician reporting data - including introducing patients to health centers and reviewing drug and laboratory prescriptions. Data analysis was performed using linear logarithm model in Rcapture package R software.

Results

In total, 134 new cases of smear-positive pulmonary tuberculosis were reported through three sources During 2016. The completeness of reporting the disease was estimated 87.5% and the incidence rate was estimated to be 11.8 / 100,000. Completeness of reporting of laboratory, hospital and physician resources were 79%, 30% and 16.3%, respectively.

Conclusion

The present study showed the necessity of evaluating the quality, completeness and linkage between data. Linking between data sources can improve the accuracy and completeness of TB Surveillance.

Background

Tuberculosis is the most common cause of death from single-factor infectious diseases and one of the ten leading causes of death in the world (1, 2). Imperfect understanding of TB epidemiology is one of the most ways for Tuberculosis (TB) control (2). Surveillance of infectious diseases as well as tuberculosis is most important for public health (3, 4). In the context of the Stop TB strategy, is vital national surveillance systems (5).

It is estimated that in 2018 around 10 million people worldwide - incidence of 130/100000 - will be affected, of which only 7 million are reported and there are 3 million differences between incidence and reporting (6). According to the 2019 report of the World Health Organization, the incidence of tuberculosis

in Iran was estimated at 14/100,000 for 2018, While 11/100,000 have been registered and reported in the same year (6). Underreporting is an important issue in the Surveillance for communicable diseases (7), which leads to underestimation of the burden of disease and can make disease control difficult (8). Post-2015 strategies by the World Health Organization emphasize the importance of universal access and enhance the effectiveness of the TB Surveillance to minimize underreporting(9). In addition, complete reporting of tuberculosis patients and subsequent timely treatment plays an important role in disease control(7). In this regard, in order to properly interpret the status of tuberculosis and its trends, the quality of disease registration and reporting should be assessed (3). There are several ways to evaluate the completeness of reporting, such as the Capture recapture method (10). The World Health Organization uses this method to estimate the incidence of tuberculosis in some countries(11). In addition, numerous studies have evaluated the completeness of reporting tuberculosis by Capture recapture method over a specific period in specific geographical areas (12). A study of the Greek city of Athens in 2016 by Albarz Pavon et al (13), a study of Baleric Iceland in 2010–2012 by Gimens et al (14), a study in Iraq in 2011 by Huseynova (15) In 2010 by Bassili et al in Yemen (16), Dunbar et al in 2007 in South Africa (17) and in study of 2001 in Liverpool, England by Tocque (18) Completeness of reporting tuberculosis was investigated using three-source Capture recapture method. The purpose of this study was to investigate the completeness of smear positive pulmonary tuberculosis reporting in Ahvaz during 2016.

Methods

Type of study

This cross-sectional study was conducted in the geographical area of Ahvaz city in Khuzestan province of Iran in year 2016. The present study is a study investigate the completeness of smear positive pulmonary tuberculosis reporting during 2016. The diagnosis of pulmonary TB patients in Ahvaz was based on the Peoples of Ahvaz diagnostic criteria for TB. The population of individuals diagnosed with Mycobacterium tuberculosis sputum specimen were enrolled in the study.

Description of study area

Ahvaz with 1.2 million inhabitants approximately, an area of 63,238 km², is the one of the largest metropolitan's city in the Iran and Middle East. Ahvaz is located in in southwest of Iran. Ahvaz is the capital Khuzestan province (19, 20). Location of the Ahvaz in southwest of Iran is presented in **figure 1**.

Data sources

Three sources were used to select patients to be included in the study.

Laboratory: Individuals diagnosed with Mycobacterium tuberculosis sputum specimen were included in the study. The data of these patients were collected from central laboratories of East and West health centers of Ahvaz and private laboratories throughout the city. The data were collected from central laboratories of East and West health centers of Ahvaz and private laboratories throughout the city.

Hospital: Patients admitted to public and private hospitals in Ahwaz city with diagnosis of TB positive. The information of these patients was extracted through hospital information system.

Physician reporting: The possibility of using more sources of information, such as prescription drugs, etc. can help in obtaining a more accurate assessment of the incidence in the community (21). To gather information from this source, both physician reporting in the form of patient referrals to health centers in the city and pharmaceutical and laboratory prescriptions were considered. In the study of the drug prescription, the condition of inclusion in the study was the prescription of complete drug administration for the treatment of the disease. In the laboratory version, all the copies that requested Acid-Fast Bacillus (AFB) or Polymerase Chain Reaction (PCR) testing were also examined. The list of people who had been asked for a test was obtained from the insurer organizations. For 643 people a test was requested in Ahvaz. All medications prescribed for the treatment of patients were also reviewed. There were 664 prescriptions for tuberculosis medication, but none contained two or more drugs. In all three sources the inclusion criteria for entering the study were a positive test response to *Mycobacterium tuberculosis* and newness of the patient.

Communication between data

At first, each source item was individually imported into Excel 2018 software. Then duplicates in each source were identified and deleted. Patients' information was merged to find commonality between the three lists. Patients' characteristics including name, surname, father's name, national code and city of residence were considered. By sorting the patients in different order (surname, first name, father's name, national code, and residence), using the Sort command and comparing each case with those recorded in another source, commonalities were identified.

Capture recapture analysis

The study was conducted using three sources Capture-Recapture method. This method estimates the total number of expected cases based on the number of unregistered cases (7). Data analysis was performed using linear logarithm model in Rcapture package R software. To estimate the number of individuals not recorded in any of the three sources, eight different linear logarithm models were fitted to the available data, and the frequency was estimated using each of these models. The linear logarithm model takes into account the dependence and heterogeneity of the resources in the calculation and is very robust when there are multiple sources (22). Logarithmic test of likelihood ratio (λ), degree of freedom, Akaike information criterion (AIC) and Bayesian information criterion (BIC) are used to check the fit of the models to the available data and to select the best model. AIC and BIC are tested by Likelihood ratio tests and lower values indicate better fit (22). The most common criterion for selecting the appropriate model is AIC (23). In cases where the sample size is low, the other two indices, in particular BIC, give better results (22).

Results

After comparing cases in three sources and eliminating common duplicates between sources - counting once in common - a total of 134 new smear positive pulmonary TB cases were recorded in three sources in 2016. The laboratory source recorded 121 cases, the hospital source 46 cases and the physician reporting source 25 cases. The distribution of the disease cases in three sources and the common cases is shown in Fig. 2.

Of these, 106 were male (79.1%) and 28 were female (20.9%), with a male to female ratio of 3.7. The highest age group was in the age group of 25–44 years with 50.7%, followed by the age group of 45–64 years with 20.8%. 97.9% were urban and 2.1% lived in rural areas. Table 1 shows the demographic characteristics of patients recorded by three sources.

Table 1
Comparison of demographic data of patients
from three sources of smear positive
pulmonary tuberculosis registry in 2016

Basic information		Number	Percentage
Gender	Male	106	79.1
	Female	28	20.9
Age	15>	0	0
	15–24	18	13.5
	25–44	68	50.7
	45–65	28	20.8
	65<	20	15

Three-source analysis was performed using linear logarithm model in R software, the results of which are presented in Table 2. In the present study, the BIC statistic was used to select a model that fits the data better, and a model that included independent effect between hospital source, laboratory and physician reporting.

Table 2
Information of linear logarithm models fitted to smear positive pulmonary TB data in 2016.

Model	InfoFit	Df	BIC	AIC	Estimate the total number of cases	95% confidence interval	Completeness of reporting in percentage
L.H.R	ok	3	59	47	153	142–164	87.5
LR.H	ok	2	61	46	145	139–151	92.4
LH.LR.HR	Warning	0	62	42	135	-	-
HR.L	ok	2	62	48	151	144–158	88.7
LR.HR	ok	1	63	46	143	137–149	93.7
LH.R	ok	2	64	49	155	143–167	86.4
LH.LR	ok	1	64	47	139	134–144	96.4
LH.HR	ok	1	67	50	151	140–162	88.7

L (Lab), H (Hospital), R (Physician Reporting), Infocrit (Indicates the presence or absence of a model error), (Degree of freedom) DF, (Bayesian Information Criterion) BIC

According to this model, the number of smear-positive pulmonary TB cases not recorded in any of the sources was estimated to be 19. As a result, the total number of smear-positive pulmonary tuberculosis cases was estimated to be 153 (134–142) in 2016. Accordingly, the Completeness of reporting rate of smear-positive pulmonary tuberculosis for all three sources was 87.5% and for each of the laboratory sources with 121 cases, the hospital with 46 cases and the physician reporting source with 25 cases were estimated to be 79%, 30% and 16.3%, respectively. Using linear logarithmic model, the incidence of disease in 2016 was estimated to be 11.8 / 100,000. A comparison between the frequency and incidence of disease in Surveillance data, data collected in the present study and linear log estimation is presented in Table 3.

Table 3
Comparison between frequency and incidence of smear positive pulmonary tuberculosis in Ahvaz

	Frequency of TB	Disease per 100,000 people
Surveillance data	128	9.8
The data of the present study	134	10.3
Linear logarithm estimation	153	11.8

Discussion

The strategy to end tuberculosis by 2030 pursues goals such as a 90% reduction in mortality and an 80% reduction in disease incidence(24). To achieve these goals, diagnosis and treatment of patients has an important role to play, which also requires an optimal Surveillance (21). In routine smear positive pulmonary tuberculosis surveillance system in the study area in 2016, the incidence rate was 9.8 / 100,000, but in the present study after collecting data from three sources and eliminating duplicates, the incidence rate was 10.3/100,000 people. The number of differences in cases were 6 patients, and after the study it was found that 4 (66%) of these patients were not included in the TB treatment system because they had died in the early days of diagnosis and treatment in the hospital. This point has been mentioned in a number of studies(25). This can have an impact on the indicators of the Surveillance, 3% in reducing the success rate of treatment and equally in increasing Mortality rate from disease. Using the linear logarithm model - a model that includes the independent effect of each source - the number of cases not recorded in any of the sources was estimated to be 19, which is consistent with the results of the Dunbar et al. Study in South Africa(17). Based on the results of this study, the completeness of reporting smear positive pulmonary tuberculosis in Ahvaz city using the data of three sources of hospital, laboratory and physician reporting was 87.5%, which is similar to the results of studies in France and Romania (12, 26) And the World Health Organization's Executive Task Force on Tuberculosis Control, which provides for the detection of at least 70% of Positive smear tuberculosis cases(17). The highest percentage of completeness of reporting (79%) was related to laboratory data, which was consistent with Vanina Guernier's study in France, Cojocaru study in Romania, and Ibarz-Pavon study in Greece(12, 13, 26).

According to a 2016 World Health Organization report, the estimated incidence of all forms of tuberculosis in Iran is estimated at 16 per one hundred thousand (27)and Therefore, considering the ratio between different forms of tuberculosis, the incidence estimated by this organization is lower than the rate calculated in this study. It should be noted, however, that this estimate is for the entire population of Iran, while the incidence and prevalence of tuberculosis is high in the marginal areas of Iran including Khuzestan province (28). The assumptions of Capture recapture studies, such as population closure, the possibility of finding commonality between sources, the independence of resources from each other, and the dependence of the catch on the specificity of the individuals at the time of these studies should be considered (17). In this study, due to the use of Excel software and sort data by name, surname and national code and manual review of all records, the default breach is that it is limited to find commonality between resources. The study also included a population closure assumption and included only patients who resided in the study area, but because this city is the center of the province, some patients may have mentioned their relatives' address at the time of hospitalization and so were included in the study. The default breach of catch dependency regarding individuals' characteristics is limited due to the widespread use of primary health care at the county level and the free diagnosis and treatment of tuberculosis.

In Capture recapture studies, by including the interaction between different sources, the effect of dependence (positive or negative) between the sources can be taken into account in the estimates and the bias due to the lack of default independence of resources can be largely eliminated (29).

In this study, the elimination of duplicates prevented overestimation and since only those with laboratory confirmation were included in the study, the accurate default of diagnosis was considered and no false positives remained in the data.

Gong et al in 2015 studied the treatment adherence among sputum smear-positive pulmonary tuberculosis patients in Xinjiang, China (30). Their result showed that among 8289 patients, 3827 men (84.4% of male patients) and 3220 women (85.7% of female patients) had good adherence during treatment follow-up. 1242 patients (15.0%) did not complete regular follow-up. 332 (4.0%) patients lost contact (30).

In another study, Smit et al estimate the completeness of notification of incident tuberculosis cases in the Netherlands (3). They reported that between 1499 tuberculosis patients which were identified, of whom 1298 were notified, resulting in an observed under-notification of 13.4% (3). Also, prediction by Log-linear capture–recapture analysis initially a total number of 2053 (95% CI 1871–2443) tuberculosis cases (3). Huseynova et al in Iraq studied on tuberculosis burden and reporting in resource-limited countries (15). Based on result this study a total of 1985 TB cases registered 1677 patients (observed completeness 84%). They investigated total number of TB cases was 2460 (95%CI 2381–2553), with identified TB cases representing 81% (95%CI 69–89) (15). Huseynova et al administrated that TB surveillance needs to be strengthened to reduce under-reporting.

In Egypt by Bassili et al evaluation of tuberculosis case detection rate in resource-limited countries (5). According result this study CDR of NTP surveillance and completeness of case ascertainment after record linkage was respectively 55% (95%CI 46–68) and 62% (95%CI 52–77). They stated that sputum smear-positive TB cases, these proportions were 66% (95%CI 55–75) and 72% (95%CI 60–82), respectively (5).

In the three-source capture analysis, data collected from each source should be more than 15% of the total catch and have sufficient overlap(17). In the present study, data from laboratory, hospital, and physician reporting sources dedicated 90%, 34%, and 18% of all cases of disease, respectively to themselves. The highest overlap was between the laboratory and hospital sources and the lowest overlap was between hospital source and physician reporting which were inconsistent with the results of the study by Dunbar et al(17). It is suggested to report the disease from the hospital and laboratory level using electronic systems in order to eliminate the challenge of not registering patients in the TB treatment system and in view of strengthening the approach of electronic medical records in recent years. In addition, the cases of tuberculosis admitted to hospital can be seasonally extracted and compared with reported cases by examining the hospital registration system. Continuous evaluation of the disease care system using the, capture recapture method is also recommended.

Limitations

This study did not cover cultural factors and economic patient information. One of the main limitation in this study was discussed only the factors that influence compliance for TB.

Conclusion

In this study we investigated the capture - recapture based study on the completeness of smear positive pulmonary tuberculosis reporting in Ahvaz city during 2016. The results of this study indicate that under-reporting of smear positive tuberculosis cases in Ahvaz is about 12.4%, while 3.9% of the cases with positive smear pulmonary TB observed in this study, which also had laboratory confirmation, were not reported, so the under-reporting would be 16.3%. Therefore, and reduce mortality by improving patient treatment compliance and improve the cure rate of the smear-positive population it is necessary. The relevant medical departments should strengthen the supervision and intervention of the TB treatment process, strengthen TB-related basic knowledge propaganda, raise awareness of TB patients, and give financial and policy support to farmers and herdsman in remote areas to improve anti-TB treatment adherence.

Abbreviations

TB
Tuberculosis
AFB
Acid-Fast Bacillus Testing
PCR
Polymerase Chain Reaction testing
AIC
Akaike information criterion
BIC
Bayesian information criterion

Declarations

Ethics approval and consent to participate

Considering the fact that the data collection method was observation and there were no human participants in the current study, obtaining informed consent is deemed unnecessary according to regulations; the Ethics Committee of Infectious and Tropical Diseases Research Center confirmed the morality and ethics of the study.

Consent for publication

Not applicable.

Availability of data and materials

Upon request, we can offer onsite access to external researchers to the data analyzed at Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. To do so, Dr. Homayoun Amiri should be contacted.

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions

HA and M-JM were principal investigators of the study and drafted the manuscript. SM-A, SH-S FH, MA and HR were advisors of the study. HA and M-JM performed the statistical analysis. All authors contributed to the design and data analysis and assisted in the preparation of the final version of the manuscript. All authors read and approved the final version of the manuscript.

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References

1. Shimeles E, Enquesslassie F, Aseffa A, Tilahun M, Mekonen A, Wondimagegn G, et al. Risk factors for tuberculosis: A case–control study in Addis Ababa, Ethiopia. *PloS one*. 2019;**14**(4).
2. Ragonnet R, Trauer JM, Geard N, Scott N, McBryde ES. Profiling Mycobacterium tuberculosis transmission and the resulting disease burden in the five highest tuberculosis burden countries. *BMC medicine*. 2019;**17**(1):208.
3. Smit F, BAARS H, De VRIES G, De HAAS P, Westenend P, NAGELKERKE N, et al. Completeness of notification of tuberculosis in The Netherlands: how reliable is record-linkage and capture–recapture analysis? *Epidemiology & Infection*. 2007;**135**(6):1021-9.
4. Dye C, Scheele S, Pathania V, Raviglione MC. Global burden of tuberculosis: estimated incidence, prevalence, and mortality by country. *Jama*. 1999;**282**(7):677-86.
5. Bassili A, Grant A, El-Mohgazy E, Galal A, Glaziou P, Seita A, et al. Estimating tuberculosis case detection rate in resource-limited countries: a capture-recapture study in Egypt. *The international journal of tuberculosis and lung disease*. 2010;**14**(6):727-32.

6. World Health Organization. Global tuberculosis report 2019. Geneva SWHO. https://www.who.int/tb/publications/global_report/en/.
7. Zhou D, Pender M, Jiang W, Mao W, Tang S. Under-reporting of TB cases and associated factors: a case study in China. *BMC Public Health*. 2019;**19**(1):1664.
8. Thrane FD, Andersen PH, Johansen IS, Holden IK. Underreporting of patients diagnosed with tuberculosis in the Region of Southern Denmark. *Scandinavian Journal of Public Health*. 2019:1403494819884433.
9. Lönnroth K, Glaziou P, Weil D, Floyd K, Uplekar M, Raviglione M. Beyond UHC: monitoring health and social protection coverage in the context of tuberculosis care and prevention. *PLoS medicine*. 2014;**11**(9):e1001693.
10. Khodadost M, Mosavi-Jarrahi A, Hashemian SS, Sarvi F, Maajani K, Moradpour F, et al. Estimating the Completeness of Lung Cancer Registry in Ardabil, Iran with a Three-Source Capture-Recapture Method. *Asian Pac J Cancer Prev*. 2016;**17 Spec No.:**225-9. [PubMed:27165230].
11. Philippe G, Charalambos S, Carel P, Katherine F. Methods used by WHO to estimate the Global burden of TB disease. *arXiv preprint arXiv:160300278*. 2016.
12. Guernier V, Guégan J-F, Deparis X. An evaluation of the actual incidence of tuberculosis in French Guiana using a capture-recapture model. *Microbes and infection*. 2006;**8**(3):721-7.
13. Ibarz-Pavón A, Papaventsis D, Kalkouni R, Metaxas G, Spala G, Georgakopoulou T, et al. Pilot study of the completeness of notification of adult tuberculosis in Athens, Greece. *The International Journal of Tuberculosis and Lung Disease*. 2016;**20**(7):920-5.
14. Gimenez-Duran J, Galmés-Truyols A, Gonzalez-Cortijo T, Bosch-Isabel C, Nicolau-Riutort A, de Mateo-Ontanon S. Estimated incidence of tuberculosis by capture-recapture in the Balearic Islands, 2010–2012. *The International Journal of Tuberculosis and Lung Disease*. 2014;**18**(11):1357-62.
15. Huseynova S, Hashim D, Tbena M, Harris R, Bassili A, Abubakar I, et al. Estimating tuberculosis burden and reporting in resource-limited countries: a capture-recapture study in Iraq. *The International journal of tuberculosis and lung disease*. 2013;**17**(4):462-7.
16. Bassili A, Al-Hammadi A, Al-Absi A, Glaziou P, Seita A, Abubakar I, et al. Estimating the tuberculosis burden in resource-limited countries: a capture-recapture study in Yemen. *The International Journal of Tuberculosis and Lung Disease*. 2013;**17**(4):456-61.
17. Dunbar R, Van Hest R, Lawrence K, Verver S, Enarson D, Lombard C, et al. Capture-recapture to estimate completeness of tuberculosis surveillance in two communities in South Africa. *The International Journal of Tuberculosis and Lung Disease*. 2011;**15**(8):1038-43.
18. Tocque K, Bellis M, Beeching N, Davies P. Capture recapture as a method of determining the completeness of tuberculosis notifications. *Communicable disease and public health/PHLS*. 2001;**4**(2):141-3.
19. Khaefi Mehran GS, Hassani Ghasem , Yari Ahmad Reza , Soltani Farhad , Dobaradaran Sina , Moogahi Sasan , Mohammadi Mohammad Javad , Mahboubi Mohammad , Alavi Nadali , Farhadi Majid , Khaniabadi Yusef Omid Association of Particulate Matter Impact on Prevalence of Chronic

- Obstructive Pulmonary Disease in Ahvaz, Southwest Iran during 2009–2013. *Aerosol and Air Quality Research*. 2017;**17**(1):230-7.
20. Nashibi R, Afzalzadeh S, Mohammadi MJ, Yari AR, Yousefi F. Epidemiology and Treatment Outcome of Mucormycosis in Khuzestan, Southwest of Iran. *Arch Clin Infect Dis*. 2017;**12**(1):e37221. doi:10.5812/archcid.37221.
21. Giménez-Duran J, Galmés-Truyols A, Luque-Fernández M-Á, Bonilla-Vargas LA, Bosch-Isabel C, Nicolau-Riutort A, et al. Assessment of tuberculosis surveillance by capture–recapture in the Balearic Islands, Spain, 2005–2007. *Enfermedades infecciosas y microbiología clinica*. 2015;**33**(9):613-6.
22. Hassan Zadeh J, Nasehi M, Rajaeifard A, Roshani D, Ghaderi E. Introduction to capture-recapture studies. *Iranian Journal of Epidemiology*. 2014;**10**(2):62-70.
23. Zemestani AR, Mahmoudi M, Keshtkaar AA, Majdzadeh SR, Foroozanfar MH, Semnani S. Estimation of Cancer Cases in Golestan Province between 2004-2006 by Using Capture-Recapture Method. *Medical Journal of Tabriz University of Medical Sciences and Health Services*. 2013;**35**(1):26-33.
24. Organization WH. Implementing the end TB strategy: the essentials: World Health Organization; 2015. Report No.: 9241509937 Contract No.: Document Number|.
25. Edginton M, Wong M, Phofa R, Mahlaba D, Hodgkinson H. Tuberculosis at Chris Hani Baragwanath Hospital: numbers of patients diagnosed and outcomes of referrals to district clinics. *The International Journal of Tuberculosis and Lung Disease*. 2005;**9**(4):398-402.
26. Cojocaru C, Van Hest N, Mihaescu T, Davies P. Completeness of notification of adult tuberculosis in Iasi County, Romania: a capture-recapture analysis. *The International Journal of Tuberculosis and Lung Disease*. 2009;**13**(9):1094-9.
27. Organization WH. Global tuberculosis report 2017. Geneva. *World Health Organization*. 2017.
28. Metanat M, Sharifi-Mood B, Alavi-Naini R, Aminianfar M. The epidemiology of tuberculosis in recent years: Reviewing the status in south-eastern Iran. *Zahedan Journal of Research in Medical Sciences*. 2012;**13**(9):1-7.
29. Motevalian A HNK, et al . . Size estimation of deaths caused by traffic accidents in the city of Kerman with Capture- recapture method. 2007:2.
30. Gong X, Li Y, Wang J, Wu G, Mohemaiti A, Wushouer Q, et al. Treatment adherence among sputum smear-positive pulmonary tuberculosis patients in Xinjiang, China: a prospective study. *RSC advances*. 2018;**8**(16):8983-9.

Figures

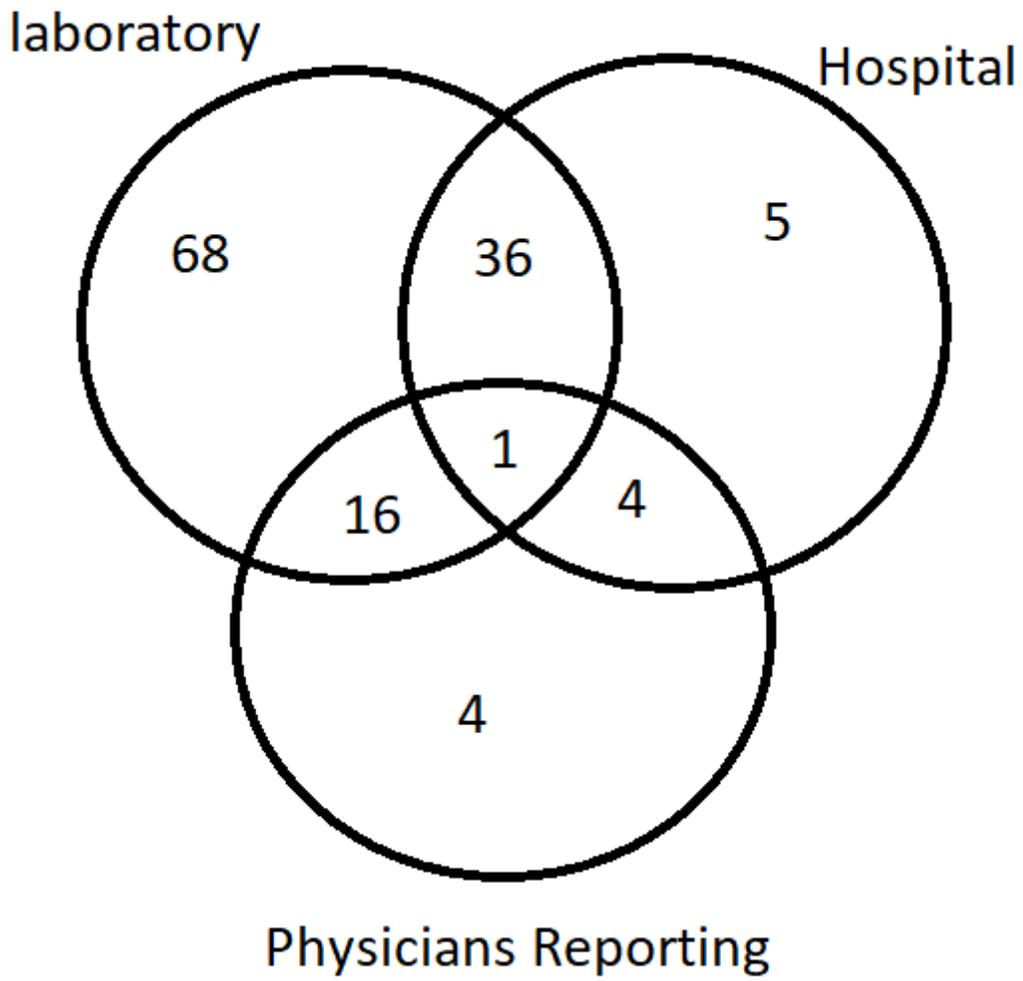


Figure 2

Distribution of smear positive pulmonary tuberculosis cases in Ahvaz city in 2016