An exploratory analysis of factors that affect TB outcomes in Nepal: A report

Incubate Nepal

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1. Introduction

Tuberculosis is a communicable disease and one of the leading causes of death worldwide and a major cause of ill health [1]. It is one of the top 10 causes of death worldwide and in Nepal, and the leading cause of death from a single infectious agent (ranking above HIV/AIDS). TB is caused by the Bacillus Mycobacterium Tuberculosis, which is spread when people who are sick with TB expel bacteria into the air; for example, by coughing. The disease typically affects the lungs (pulmonary TB) but can also affect other sites (extrapulmonary TB).
An estimated 10.6 million people developed TB and 1.6 million died from TB worldwide in 2021 [2]. About a quarter of the world's population is infected with M. tuberculosis which is similar for Nepal. Nepal has been listed among the 30 high Tuberculosis (TB) burden countries worldwide. The NTP Prevalence Survey Report 2020 estimated TB prevalence of 416/100000 with around 117000 people living with TB in Nepal [3]. The National Tuberculosis Program (NTP) in Nepal is a program of the Ministry of Health and Population (MoHP) that is dedicated to achieving the targets of the "End TB" strategy by 2030. Despite consistently high treatment success rates of 90 percent, finding missing TB cases and expanding high-sensitivity diagnostic services remain big challenges in Nepal [4].

The standardized TB treatment regimen of 6-8 months can cause many side effects and patients could find it difficult to adhere to the regimen. This often leads to non-adherence to medication which could cause higher relapse rates, the development of drug-resistant forms of TB, and higher TB transmission rates.
Directly Observed Therapy Short course (DOTS) refers to a TB treatment strategy in which the patient taking the medicine is observed by a health personnel and the taking of medicine is recorded. Therefore, DOTS can help patients adhere to the regimen and take medications on time. DOTS is composed of five distinct elements: political commitment; microscopy services; drug supplies; surveillance and monitoring systems and use of highly efficacious regimens; and direct observation of treatment [5]. DOTS is endorsed by the WHO as a proven, cost-effective TB treatment strategy that breaks the cycle of transmission. DOTS has been an effective strategy in large and small countries, both rich and poor. In China, cure rates rose from below 50 percent to more than 95 percent covered by DOTS [6].

DOTS have been successfully implemented throughout Nepal since April 2001 and DOTS services in Nepal are provided by the government through DOTS centers and sub-centres. The National Tuberculosis Programme (NTP) is fully integrated with the general primary health care system of the Government of Nepal and the National Tuberculosis Control Centre is at the forefront of the NTP. This research paper aims to analyze the effectiveness of DOTS and TB outcomes in Nepal using various studies and reports.

2. Methods

This research study utilized a combination of data sources and analytical approaches to investigate the topic of Tuberculosis (TB) prevention, care, control, and the effectiveness of Directly Observed Treatment, Short-course (DOTS). The data collection and analysis methods employed are described below.

2.1. Data Collection

The published data from the National TB Control Centre for the period of 2075-76 was accessed and utilized as a primary data source.

· Information from the HMIS annual reports and the TB fact sheet report of 2077-2078 was also included in the analysis.

· Additionally, the latest data on TB patients for the years 2079-2080 was collected from the district hospital in Jaleswar, Mahottari.

2.2. Data visualization

· R, a statistical programming language, was utilized for data visualization, analysis, and conducting statistical tests.

· The ggplot2 library was employed for data visualizations, allowing for a clear and informative graphical representation of the data.

2.3. Statistical modeling

· Simple and multiple linear regression models were employed as the statistical tools for this study.

· These regression models were utilized to establish and explore the relationships between the variables identified in our research.

2.4. Literature Review

A comprehensive review of the available literature on Tuberculosis prevention, care, control, and the availability and effectiveness of DOTS was conducted.

· Both national and international papers were examined to gather insights into the subject matter.

By employing a combination of data collection, literature review, and statistical analysis using R and regression modeling techniques, this study aimed to gain a deeper understanding of the factors related to TB prevention, care, control, and the effectiveness of DOTS.

3. Results

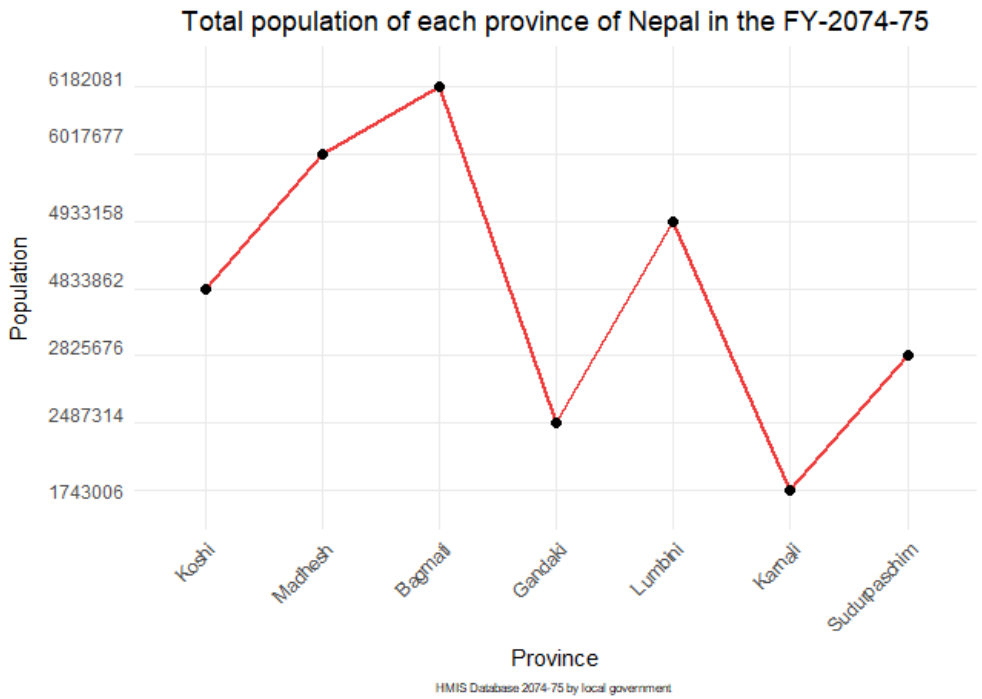
INDEX 1: HMIS Database 2074-75 by local government

The report is based primarily on data gathered by NTCC through HMIS, NTP MIS, WHO country profile, National TB prevalence survey 2018-19 report, and other surveillance data.

With a total population of 29022774 in the fiscal year 2074-75, Nepal's population spreads over seven different provinces. Province 3 has the highest population with 21.3% of the country's total population and Karnali Province contains the lowest population i.e. 6.0% of the country's total population.

Table 1. Total population of each province of Nepal in the FY-2074-75

Province #	Province name	Population	Proportion of country's population (%)
1	Koshi	48,33,862	16.7
2	Madhesh	60,17,677	20.7
3	Bagmati	61,82,081	21.3
4	Gandaki	24,87,314	8.6
5	Lumbini	49,33,158	17.0
6	Karnali	17,43,006	6.0
7	Sudurpaschim	28,25,676	9.7
Total		**2,90,22,774**	**100**

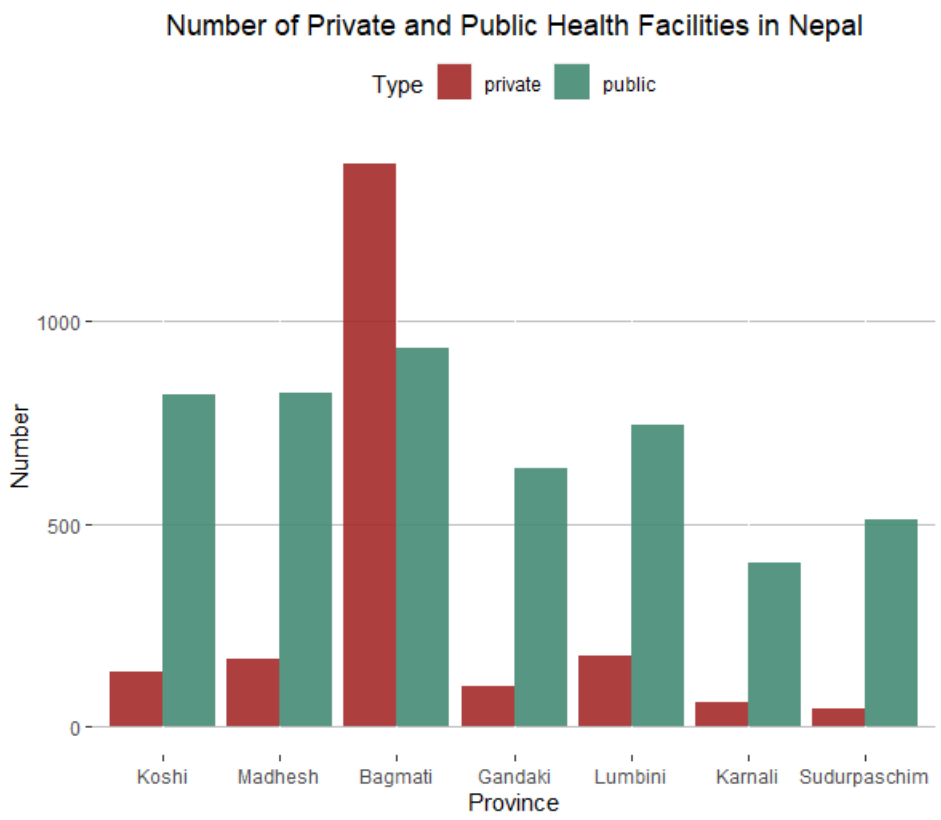


It's important that all provinces in Nepal have the right amount of health facilities and clinics according to their needs. Since most of the population lives in Province 3, having all the health facilities centralized in the province isn't a good sign for the successful eradication of TB. From our primary qualitative data collection, we found that most of the people in rural areas of Nepal aren't aware of health facilities in their areas. The table below analyzes the number of health facilities in all the provinces of Nepal to understand how well-equipped each province is in general in terms of health infrastructure.

Table 2: The number of health facilities in different provinces

Province #	Province name	No. of public health facilities (hospitals, primary health care centers, health posts, etc)	No. of public health facilities/total population of the province (*100)	No. of non-public health facilities
1	Koshi	816	0.017	136
2	Madhesh	822	0.014	169

3	Bagmati	934	0.015	1386
4	Gandaki	635	0.026	101
5	Lumbini	741	0.015	174
6	Karnali	404	0.023	60
7	Sudurpaschim	511	0.018	45



Establishing the relationship and comparing the effectiveness of public health facilities and non-public health facilities

In Province 3, the number of private health centers is more than the number of public health centers. In the other six provinces, the number of public health facilities is dominant. There is no definitive way of knowing which of the centers is more effective. However, the dominant number of Private hospitals could be one of the reasons why the TB burden and control is more feasible in Province 3. Moreover, it's important to understand that both the public and private sectors are equally responsible for controlling TB burden.

Prevention is better than cure. Understanding the need for early prevention and early efforts to End TB, 95,215 children were immunized with the BCG vaccine in the 2074/75 fiscal year in Province 1 of Nepal according to a database mentioned in *INDEX 1*. The highest number of immunized children was in Province 2 with 1,28,974. Similarly, the lowest was Karnali with 39,202 children. A total of 5,73,796 children were vaccinated with the BCG vaccine with the breakdown as follows:

Province-1: 95,215
Province-2: 1,28,974
Province-3: 1,09,095
Gandaki: 41,646
Province-5: 1,05,703
Karnali: 39,202
Sudurpaschim: 53,961

Next important evidence that DOTS is a great TB preventive strategy is that in all the provinces of Nepal in the fiscal year 2074/75, the TB treatment success rate is over 80%, with the highest rate in province 3 with 86% and the lowest in Province 2 with 80.6%. Karnali reported the least number of TB PBC (new) registered cases among which 405 completed treatment and were cured. Province-5, on the other hand, reported the highest TB cases with 2979 among which 2594 completed treatment and cured. A short summary of the data can be found below:

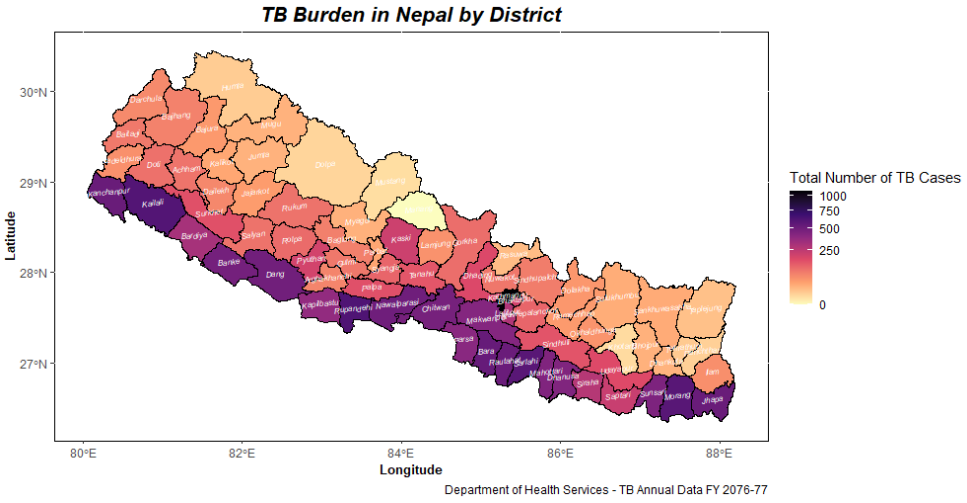
Table 3:

Province	No. of new TB cases	TB PBC (new) registered cases	% of the total population with PBC cases	TB PBC (new) treatment completed and cured	Treatment success rate
Koshi	3587	1720	0.04	1524	88.6
Madhesh	4542	1979	0.03	1595	80.6
Bagmati	6118	2771	0.04	2384	86
Gandaki	1857	877	0.04	774	88.3
Lumbini	5772	2979	0.06	2594	87.1
Karnali	1383	471	0.03	405	86
Sudurpaschim	2616	1385	0.05	1229	88.7

These data have been collected from every municipality and ward from every corner of the country. The most important thing that can be taken away from the data shown is that if TB is diagnosed and treated in a systematic way, with the best use of resources and strategies like DOTS, TB is curable and Nepal can be a contributor to the End TB strategy. Unfortunately, in many parts of Nepal, people are unaware of DOTS clinics and are forced to travel miles, multiple times to the central NTCC.

Regression models that can possibly be developed from the above data

1. TB outcomes in children vs Number of children vaccinated with BCG
2. Time taken for TB treatment vs Number of co-infection cases
3. TB outcomes vs Population



INDEX 2: Tuberculosis-raw-analyzed-data-FY-2076-77

This dataset primarily focuses on the new, relapse, and retreatment of PBC, PCD, and EP TB cases from the years 2076-77. Province 2 reported the highest number of new PBC TB cases in the year 2076-77 with a total number of 3173 infected people. The highest number of relapse PBC cases was in Province 3 with a total number of 313 infected people. The number of new and relapse PCD cases is subsequently lower in all the seven provinces compared to the PBC TB, with the highest number of new registered cases being 926 in Province 2. The total number of PBC registered new cases in the country was 13582 whereas the total number of PCD registered new cases was only 457. The gap between the number of relapses and retreatment is extremely high in both PBC and PCD TB. The biggest gap was in province 5 for PBC where only 45 patients took the retreatment out of 294. A summary of the data can be found below:

Table 4:

Province	New PBC	Relapse PBC	Retreatment PBC	New PCD	Relapse PCD	Retreatment PCD
Koshi	1794	173	45	457	19	5
Madhesh	3173	153	72	926	24	7
Bagmati	2840	315	80	659	33	8
Gandaki	918	124	19	247	25	4
Lumbini	2861	294	45	821	25	10
Karnali	509	61	19	209	4	7
Sudurpaschim	1487	152	51	284	8	8

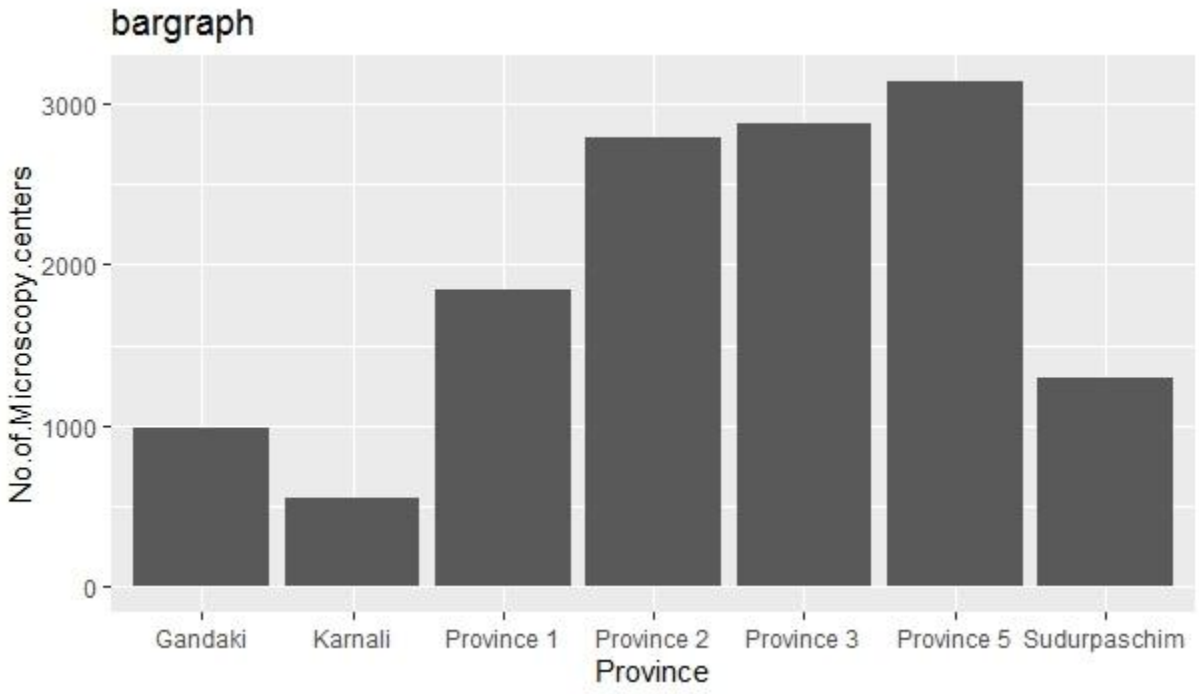
INDEX 3; TB-FACT-SHEET-2077-78

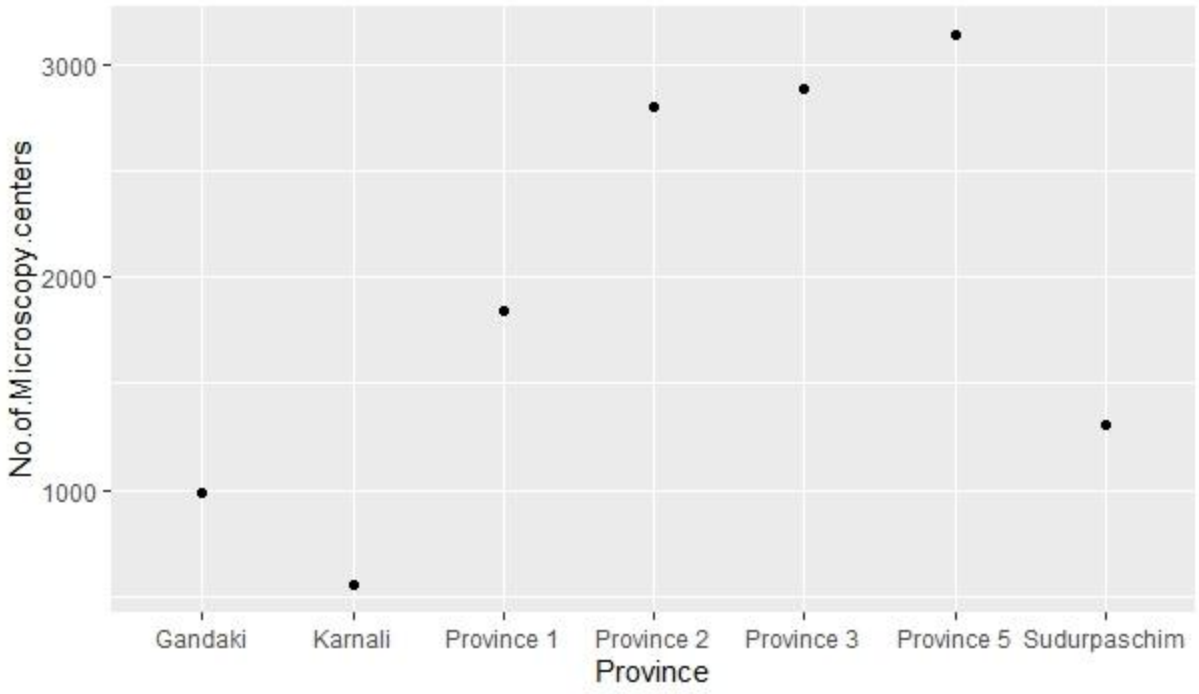
This datasheet contains all the relevant information about the number of DOTS clinics and other important health facilities in all the seven provinces of Nepal. DOTS clinics play a major role in the successful treatment of TB. All seven provinces of Nepal are pretty well equipped with DOTS clinics and other TB facilities like MDR treatment sites, Microscopy Centres, and GeneXpert facilities. Bagmati Province has the highest number of DOTS clinics and MDR treatment sites. Microscopy Centers and GeneXpert facilities with 1099, 24, 260, and 19 centers respectively. The table below shows all the center numbers in each province.

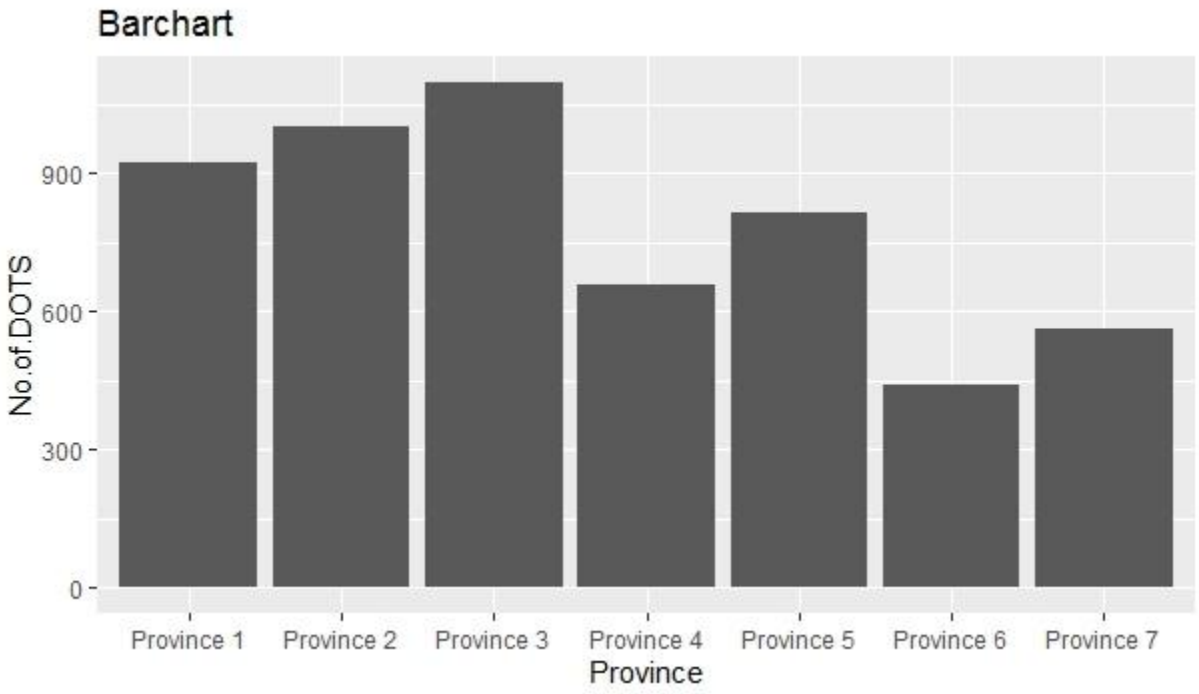
Table 5:

Province	Number of DOTS	Number of MDR centers	Number of MDR Sub-centres	Microscopy Centers	GeneXpert Facility
Koshi	925	4	12	83	13
Madhesh	1003	3	18	94	18
Bagmati	1099	2	24	260	19
Gandaki	657	3	10	61	6
Lumbini	814	3	13	171	17

Karnali	442	2	2	47	4
Sudurpaschim	563	5	2	180	7
Total	5503	22	81	896	84




3000
2000
1000
No.of.Microscopy.centers
Gandaki
Karnali
Province 1
Province 2
Province 3
Province 5
Sudurpaschim
Province


Barchart
900
600
300
0
No.of.DOTS
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Province 2
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Province 4
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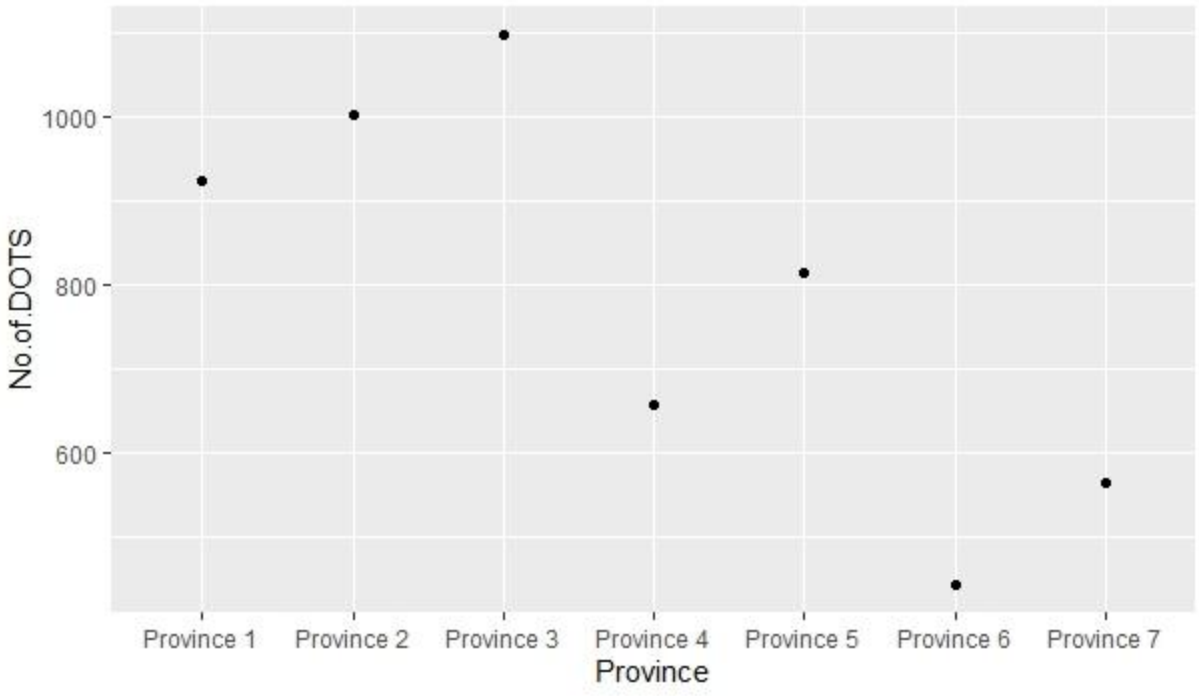


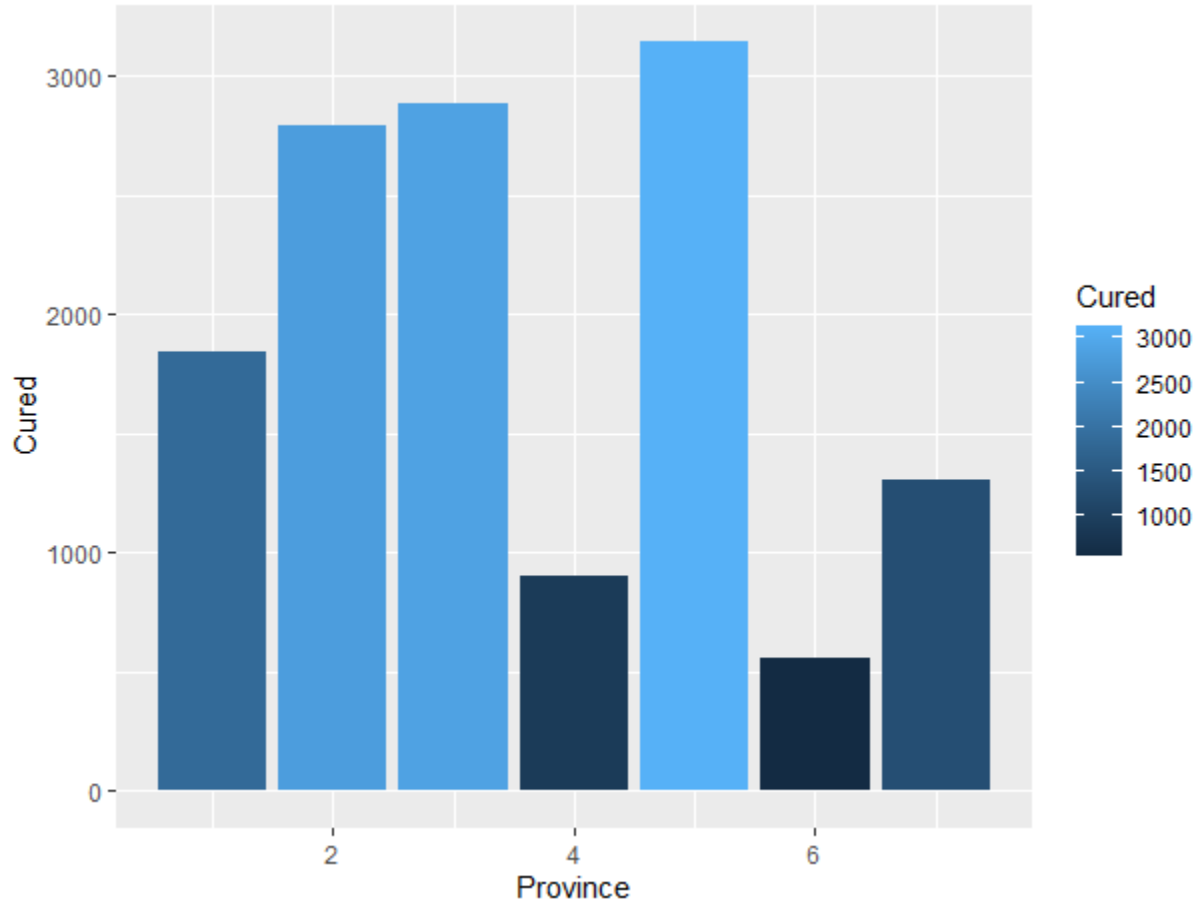
INDEX 4: TB Data Annual 2074-75

This dataset essentially contains the total number of **registered** and **cured** PBC cases in all the provinces of Nepal.

Table 6:

Provinces	Registered	No. of registered/Total population (X100)	Cured	No. of cured/No. of registered
Koshi	2124	0.04	1842	0.87
Madhesh	3526	0.06	2794	0.79
Bagmati	3387	0.05	2880	0.85
Gandaki	1016	0.04	900	0.89
Lumbini	3624	0.07	3140	0.87
Karnali	626	0.04	555	0.89

Sudurpaschim	1578	0.06	1303	0.83



INDEX 5: Population data

INDEX 6: Pokhara data

INDEX 7: Jaleshwar data

Jaleshwar Hospital (2079-80)
Total cases - 105
Male - 73
Female - 32
Relapse cases - 2
Referred: Self - 82

Contract invest - 15
Private hospital - 8

Disease type:
PCB + New: 56
PCB: 2
PCD + New: 33
PCD : 3
ED + New: 11

This is the data of Jaleshwar Hospital of 2079-2080 where a total of 105 TB cases were recorded during the study period. Out of these cases, 73 were male and 32 were female. Among the cases, there were two instances of relapse.

The study observed that the majority of patients (82 cases) arrived at the hospital without any external referrals, while 15 cases were contracted through investment, and 8 cases were treated at private hospitals before being referred to Jaleshwar Hospital.

The data further analyzed the disease types observed among the patients. The most common disease type was "PCB + New" with 56 cases, followed by "PCB" with 2 cases, "PCD + New" with 33 cases, and "PCD" with 3 cases. Additionally, there were 11 cases of the "ED + New" disease type.

The findings from this analysis provide valuable insights into the patient demographics and disease distribution at Jaleshwar Hospital during the specified timeframe of 2079-80. These observations can be used to enhance the hospital's understanding of patient trends and improve healthcare services in the future.

4. Discussion

- Graph coloring theorem

Limitations:

The paper primarily relied on secondary data available on the HMIS and NTCC official websites. To establish the relationship between the availability of DOTS clinics and other health facilities and TB outcomes, different sets of data from different fiscal years were used. To calculate the number of DOTS and other health facilities across different provinces, the TB fact-sheet 2077-78 datasheet was used while data from previous years (data from 2074, 2075, and 2076) were used to calculate TB outcomes (new cases, relapse cases, PBC and PCD cases). It was assumed that the number of health facilities in the years typically ranging from 2074-2078 were

not significantly different. This could be an over-estimated number of health facilities. Similarly, the population data of the fiscal year 2074-75 was used to compare with the number of DOTS clinics and other health facilities from the year 2077-78.

No matter what the number of health facilities and DOTS clinics across different provinces, the TB success rate tends to be above 80% and the paper has not yet been able to identify other parameters to establish a clear relationship between TB outcomes and health facilities. Similarly, the paper has not been able to establish relationships between some parameters like the percentage of children immunized with BCG vaccines in different provinces and TB outcomes among children. This is primarily because of the unavailability of such data. Other data like 'xyz' were also not available so it was difficult to establish a clear relationship between the required parameters to prove our hypothesis.

Some of the data used, even from a reliable source like HMIS, contains some big errors. For example in Sankhuwasabha district in the year 2074-75, the TB treatment rate is 183% suggesting that there has been some error collecting the data.

Also, some regression models that were made using 'R' to support the hypothesis, have a 'P-value' of more than 0.05, meaning that the model is not statistically significant.

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