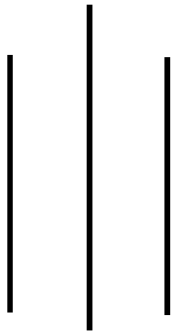
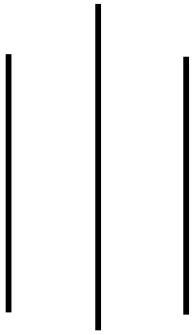
Leveraging Portable Digital X-Ray to Strengthen TB Case Finding among People Living with HIV in Gandaki Province of Nepal



Submitted To
Nepal Health Research Council
Kathmandu



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June, 2026

SELF-DECLARATION

This research project entitled "**Leveraging Portable Digital X-Ray to Strengthen TB Case Finding among People Living with HIV in Gandaki Province of Nepal**" is original, unpublished, independent work by the authors. The data mentioned in the research has been generated during research work and are genuine. The results embodied in this research, researchers have not been submitted to any other institution or university for obtaining any degree or financial benefits.

……..

Signature

Dr. Amar Nagila

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Date: 10th June, 2026

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At last, but not the least, I want to impart a vote of thanks to PCDC, Gandaki province and ART center, for their cooperation and support during data collection. I would like to acknowledge, all the participants who participated in the study without which the study would not have been possible.

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Date: 10th June, 2026

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ACRONYMS

AI	Artificial Intelligence
AIDS	Acquired Immunodeficiency Syndrome
AMR	Antimicrobial Resistance
ART	Antiretroviral therapy
BMI	Body Mass Index
CAD4TB	Computer-Aided Detection for Tuberculosis
CD4	Cluster of Differentiation 4
CI	Confidence Interval
CVD	Cardio-vascular Disease
DOTS	Directly Observed Treatment Short course
EP	Extra-pulmonary Tuberculosis
HIV	Human Immunodeficiency Virus
MDR-TB	Multi-drug Resistant Tuberculosis
mWRD	molecular WHO-recommended Rapid Diagnostic Test
MTB	Mycobacterium tuberculosis
NHRC	Nepal Health Research Council
PAHS	Pokhara Academy of Health Sciences
PCD	Pulmonary Clinically Diagnosed
PLHIV	People Living with HIV
PTB	Pulmonary TB
STAC	SAARC Tuberculosis and HIV/AIDS Centre
TB	Tuberculosis
WHO	World Health Organization

ABSTRACT

Introduction: Tuberculosis (TB) and Human Immunodeficiency Virus (HIV) remain pressing global public health challenges, particularly in low- and middle-income countries like Nepal. TB is the leading cause of death among people living with HIV (PLHIV), accounting for a significant proportion of AIDS-related deaths. The co-infection of TB and HIV presents complex challenges, including delayed diagnosis, overlapping drug regimens and increased risk of mortality. Despite progress, Nepal continues to face a high burden of TB, including multidrug-resistant TB (MDR-TB), with limited early detection tools for high-risk groups such as PLHIV. This study aimed to strengthen TB case finding among PLHIV in Gandaki Province by leveraging portable digital X-ray technology integrated with CAD4TB (Computer-Aided Detection for Tuberculosis).

Methods: A cross-sectional survey was conducted among HIV-positive patients attending (Antiretroviral Therapy) ART centers across diverse ecological regions (mountain, hill, and Terai districts). All participants were undergone digital chest X-ray screening and presumptive TB cases were confirmed through Gene-Xpert testing at the Provincial Tuberculosis Control Center. A total of 260 participants were enrolled. Ethical approval was obtained from the Institutional Review Committee (IRC), Pokhara University (105/2082/83) and relevant authorities.

Findings: The study done among 260 people living with HIV registered in different ART center, demonstrated that study participants comprise of 58.5% (n=152) and 41.5% (n=108) female and males respectively. The majority were aged below 45 years (46.2%), followed Hindu religion (75.4%), from urban areas (75.0%), and living in nuclear families (84.6%). The Gene-Xpert test revealed that 81.1% (n=30) tested negative for MTB, while 16.2% (n=6) tested positive. Among positive cases, MTB was detected with high bacterial load (8.1%), medium bacterial load (5.4%), and very low bacterial load (2.7%). Majority of participants (60.8%) had normal body mass index. Also, digital chest X-ray screening was found to be normal among 85.8% of participants, while 14.2% of participants were suggestive of active or old tuberculosis (TB). The Gene-Xpert positivity rate was found to be 18.92%. This study found the TB prevalence as 2.69% (7/260) and 42.3% were having comorbidities. The bivariate analysis sex, ethnicity, alcoholic history, comorbidities, viral load, close contact with TB patient and symptoms of TB as predictors of TB infection among

PLHIV. However, after adjustment in multivariate analysis ethnicity was identified as a main predictor for getting TB.

Conclusion:

This study determined the prevalence of TB infection and association with different relevant factors among people living with HIV in Nepal. The findings emphasize the importance of strengthening active TB screening and comprehensive assessment, of associated risk factors among PLHIV using the portable digital X-ray in order to design the targeted interventions for high-risk subgroups and ensure timely treatment. It is crucial for the achievement of national target of ending TB. These evidences suggest the early and efficient way of strengthening the active TB case findings by use of available resources such as digital chest X-ray. This insight should be incorporated into future HIV/TB control programs to reduce the financial burden of screening TB among PLHIV in Nepal by using portable digital X-ray.

Keywords: Digital X-ray, TB, HIV, AIDS

CHAPTER I: INTRODUCTION

1.1 Background

Tuberculosis (TB) remains a considerable global public health problem, mainly affecting poor and vulnerable populations. Tuberculosis is a highly infectious and chronic disease caused by the bacillus mycobacterium tuberculosis (1,2), which infects almost all body tissues and organs, but pulmonary tuberculosis (PTB) is the most common form (3). Tuberculosis has re-emerged as one of the most significant infectious diseases of modern times, after more than a century of declining incidence and mortality (4).

Human Immunodeficiency Virus (HIV) remains a significant global public health challenge, with an estimated 650,000 deaths due to HIV-related causes reported in 2021(5). According to the latest data from the World Health Organization (WHO), tuberculosis (TB) accounts for approximately 30% of the 690,000 AIDS-related deaths worldwide (6). In 2024, an estimated 10.8 million people developed TB, with 8.2 million officially diagnosed. Of those diagnosed, 8.2% were living with HIV. In 2023, TB caused around 1.25 million deaths, including 161,000 among people living with HIV (1).

Tuberculosis (TB) and human immunodeficiency virus (HIV) pose major global health challenges, especially in developing countries like Nepal. The dual burden of TB and HIV has serious public health implications and calls for targeted and integrated interventions. According to the World Health Organization's Global TB Report 2023, Nepal continues to face a significant TB burden, including a growing number of multidrug-resistant TB (MDR-TB) cases (7).

Tuberculosis is an opportunistic infection (OI), meaning it occurs more frequently or severely in individuals with weakened immune systems. Human Immunodeficiency Virus (HIV) weakens the immune system, significantly increasing the risk of developing TB. When a person is infected with both HIV and TB, it is referred to as HIV/TB co-infection. In such cases, latent TB is more likely to progress to active TB disease compared to those without HIV, making early diagnosis and treatment critical for both conditions (8,9).

TB/HIV co-infection increases the risk of poor treatment outcomes, including death, loss to follow-up, treatment failure, drug-resistant TB, and failure to achieve viral load suppression.

Treatment becomes more complicated due to overlapping drug regimens, more side effects, and a higher number of pills, which can reduce medication adherence. People with TB/HIV co-infection are also at higher risk of immune system decline, other infections, and death. To overcome these challenges, integrated care and patient-centered support are essential to improve adherence and treatment outcomes (10,11).

Leveraging portable digital X-ray technology integrated with CAD4TB (Computer-Aided Detection for Tuberculosis) can significantly strengthen TB case finding among people living with HIV in Nepal. This approach enables early identification of TB disease, timely initiation of appropriate treatment, and improved case-holding. Currently, digital X-ray with CAD4TB is not routinely used for TB screening among HIV-positive individuals. Introducing this tool for TB screening in presumptive cases would facilitate early-stage diagnosis, thereby contributing to more effective control of TB transmission (12–14).

1.2 Problem Statement

Tuberculosis (TB) remains a serious public health challenge, with its resurgence marking a setback in global health progress. This trend reflects the growing threat of antimicrobial resistance (AMR) and disproportionately impacts vulnerable populations, particularly people living with HIV. Due to compromised immune function, individuals with HIV are significantly more susceptible to TB infection and experience higher rates of morbidity and mortality. Early detection and prompt treatment are essential to reducing transmission and improving outcomes in this high-risk group. Chest X-ray is considered as a highly sensitive screening tool for detecting tuberculosis and guide the effective molecular WHO-recommended rapid diagnostic tests (GeneXpert). Earlier, chest X-ray played significant role in diagnosing pulmonary TB at health facility setting. However, with increasing burden of TB in low-middle-income countries like Nepal and the international commitment to end global TB epidemic by 2030, clearly highlight the need of active case findings of TB (15). Moreover, with recent advancement on digital technology and artificial intelligence the integration of CXR along with the portable AI assisted technology to diagnose TB is expected to enhance diseases predictability and reduce human error (16).

Nepal Tuberculosis Control Center, the central body for tuberculosis control in Nepal has also adopted and endorsed CD4TB (computer-aided diagnosis for TB), an artificial intelligence software integrated with an ultraportable X-ray modality for community screening of tuberculosis (17). In this context, leveraging portable digital X-ray technology

integrated with CAD4TB (Computer-Aided Detection for TB) provides a promising solution. Incorporating this tool into routine HIV care can strengthen TB case finding, enable timely diagnosis and support more effective TB control efforts in Nepal. Conversely, HIV patients have a heightened susceptibility to TB due to compromised immune function, making them more susceptible to infection. Active screening for both diseases can reduce TB transmission and prevent the development of complications of HIV.

1.3 Objectives

1.3.1 General objective

The general objective of the study was to determine the prevalence of tuberculosis among HIV patients.

1.3.2 Specific objectives

The specific objectives were:

- To improve early diagnosis of active TB cases among people living with HIV through the use of portable digital X-ray technology integrated with CAD4TB.
- To identify factors associated with TB among People Living with HIV Patients.

Conceptual Framework

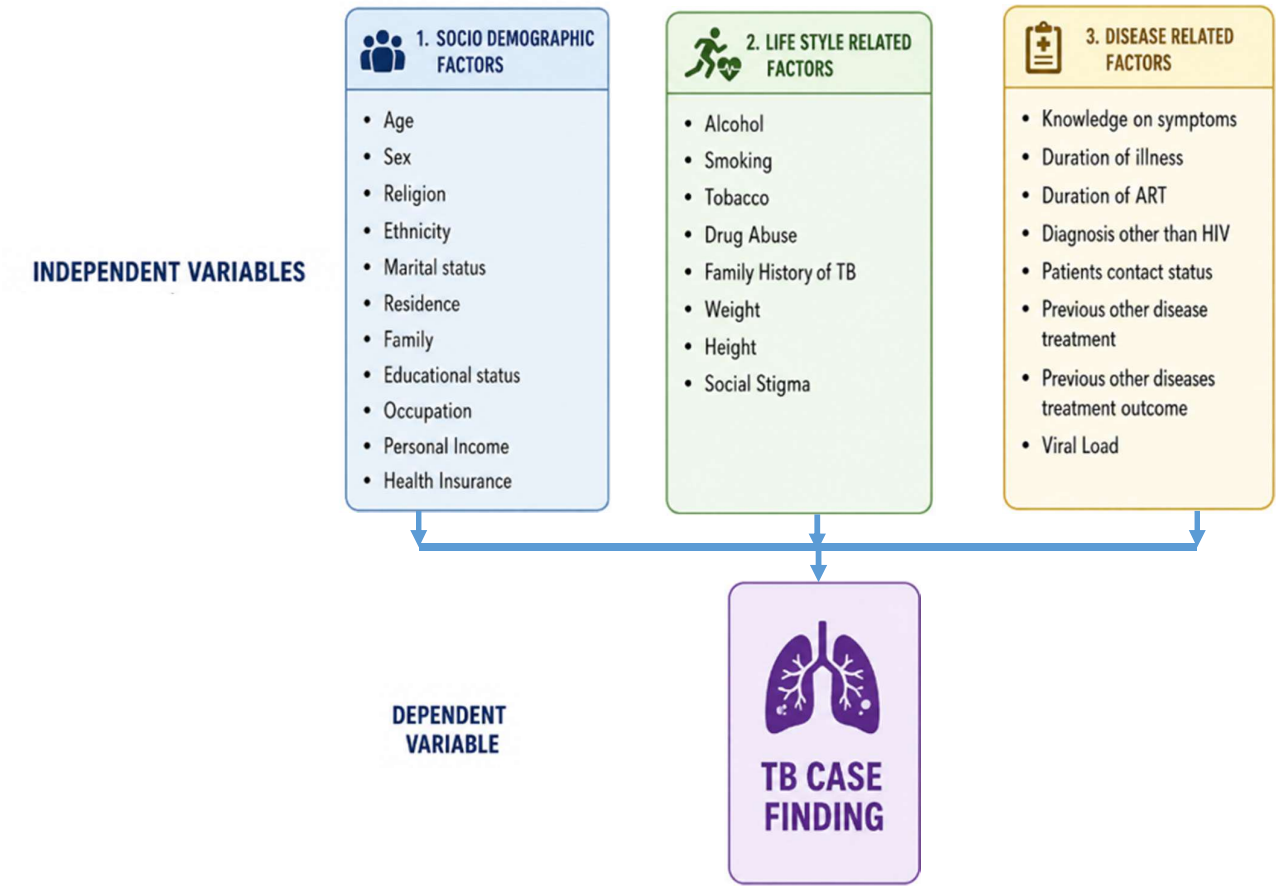


Figure 1: Conceptual framework of the study

Study Variables

Independent Variables

Socio Demographic factors

- Age
- Sex
- Religion
- Ethnicity
- Marital status
- Residence
- Family

- Educational status
- Occupation
- Personal Income
- Health Insurance

Life Style Related Factors:

- Alcohol
- Smoking
- Tobacco
- Drug Abuse
- Family History of TB
- Weight
- Height
- Social Stigma

Disease Related Factors

- Knowledge on symptoms
- Duration of illness
- Duration of ART
- Diagnosis other than HIV
- Patients contact status
- Previous other disease treatment
- Previous other diseases treatment outcome
- Viral Load

Dependent Variable: TB Case finding

CHAPTER II: LITERATURE REVIEW

2.1 Introduction

Tuberculosis (TB) is an infectious disease with impact on global public health. It needs to be diagnosed on time and enrolled for treatment in order to achieve the national and global commitment of end TB. There is rapid decrement in immune cells among people living with HIV which increases the risk of developing TB among them. TB continues to be a major co-infection among people living with HIV (PLHIV) in Nepal, contributing significantly to morbidity and mortality. The diagnosis and treatment of tuberculosis among PLHIV is challenging but highly relevant for achieving the committed target. The main objective of this literature review was to review articles related to prevalence of TB among PLHIV using AI assisted technology for diagnosis and assess the socio-demographic, lifestyle, behaviour, and stigma related factors associated with presence of TB.

2.2 Literature search

All the relevant articles were searched using various databases such as Google Scholar, PubMed, and Scopus. The search was conducted using the relevant key words for the study.

2.3 Findings

A cross-sectional study conducted among people living with HIV at the selected Antiretroviral Therapy Center of West Bengal, India 2022 demonstrated that transgender (OR: 2.9, 95% CI: 1.4-6), males (OR: 3.7, 95% CI: 1.8-7.9). widow/separated (OR: 2.5, 95% CI: 1.2-5.4), living with family members (OR: 1.6, 95% CI: 1-2.7), CD4 count less than 200 (OR: 1.9, 95% CI: 1.1-3.2), those who received CPT (OR: 17, 95% CI: 7.1–40.8) and those who didn't receive TPT (OR:1.6, 95% CI:1–2.6) were independently associated with increased risk of developing TB. There was no significant association of age with TB diagnosis among the PLHIV(18).

The cross-sectional study done among 32,168 HIV-positive patients diagnosed in Iran to determine the predictors of TB and HIV coinfection revealed that the prevalence of TB in HIV patients as 3.2% with higher among females (91.83%). Similarly, male gender (OR=1.91), injecting drug use (OR= 1.46), illiterate or primary/university (OR= 2.23), and high school/university (OR=2.24) increased the risk of TB and HIV coinfection ($p<0.05$) (19).

The study done in 2018 to assess the prevalence of TB among PLHIV and factors associated with it showed that 9.9% of prevalence of TB, with significantly higher risk of getting TB among males than females (13.6% Vs 5.8%; P = 0.02), and Dalit ethnic background as compared to Brahmin/Chhetri (22.0% Vs 5.9%, P = 0.01). Also, the risk of getting TB among those with HIV stage progressed to WHO stage 3 and 4 (OR = 4.85, P<0.001) and with the family history of TB (OR = 4.50, P = 0.002) (20).

The study conducted to identify risk factors of TB infections among people living with HIV/AIDS in Burkina Faso in 2010 using cross-sectional consecutive design showed that 24.7% of HIV infected had co-infection of TB. Likewise, people with CD4 cell counts below 200/µl, a history of sexually transmitted infections and past or present history of pulmonary asthma were identified as adjusted TB risk factors. Male gender, jobs not in the private and public sector, and history of cardiovascular disease were determined as additional risk factors for TB (21).

A case-control study conducted from January to March, 2009 in South West Ethiopia among 162 cases and 647 controls of HIV/AIDS infected people with and without active tuberculosis respectively showed male gender (OR=1.7; 95%CI: 1.1, 2.7), a low level of education (OR=2.8; 95% CI: 1.1, 7.1), a body mass index less than 18.5 kg/m2 (OR=4.1; 95% CI: 2.3, 7.4), hemoglobin level less than 10.0 g/dl (OR=2.8; 95%CI: 1.5, 5.2), a CD4 lymphocyte count less than 200 cells/µL (OR=9.8;95% CI: 5.5, 17.5), a WHO clinical stage IV (OR=4.3; 95% CI: 2.6, 6.8), not taking antiretroviral treatment (OR=3.1; 95% CI: 1.9,4.9), an infection with helminthes (OR=2.2; 95% CI: 1.4, 3.4), a history of contact with a tuberculosis patient in the family (OR=2.0; 95% CI: 1.2, 3.3), and living in a house made of mud wall (OR=3.7; 95% CI: 1.5, 7.5) were independently associated with the development of active tuberculosis in people living with HIV/AIDS (22).

A cross-sectional study conducted among 326 people living with HIV to determine the prevalence of TB co-morbidity and their determinants among HIV sero-positive individuals in Shegaw Motta district hospital Ethiopia showed that the prevalence of TB/HIV co-infection was 18.1%. Similarly, patients drinking alcohol (AOR=2.36, 95% CI=1.07–5.19), BMI< 16 (AOR= 19.13, 95% CI=4.14–88.36), World Health Organization (WHO) clinical stage IV (AOR=23.02, 95% CI=3.76–140.97), bedridden (AOR=13.79, 95% CI=5.44–

34.95) and ambulatory functional status (AOR=5.30, 95% CI=1.87–15.05) were significant predictors for TB/HIV co-infection (23).

A retrospective study done among 514 HIV-positive patients at Hiwot Fana hospital from December, 2014 to 2018 showed that 37.4% had TB. Also, HIV patients with regards to marital status (AOR = 2.6; 95%CI = 1.19–2.89), education status (AOR = 3.74; 95%CI = 2.47–5.66), weight less than 50kg (AOR = 2.54; 95% CI = 1.35 – 4.81), CD4 level < 200cells/mm3 (AOR = 4.57; 95%CI = 2.38– 6.86) and patient who were at WHO clinical stage III (AOR = 7.8; 95%CI = 5.15 – 8.55) were found to be significantly associated with TB/HIV co-infection (24).

CHAPTER III: METHODOLOGY

3.1 Study Design

The study design was a health facility-based cross-sectional study conducted among people living with HIV who were attending various ART centers across Gandaki Province. All participants were undergone radiological screening using portable digital X-ray technology integrated with CAD4TB (Computer-Aided Detection for Tuberculosis), followed by laboratory confirmation using the Gene-Xpert test.

3.2 Study Methods

Study method was quantitative. Semi structured questionnaire was used for collecting primary data through face-to-face interview.

3.3. Study Process (Flow Diagram)

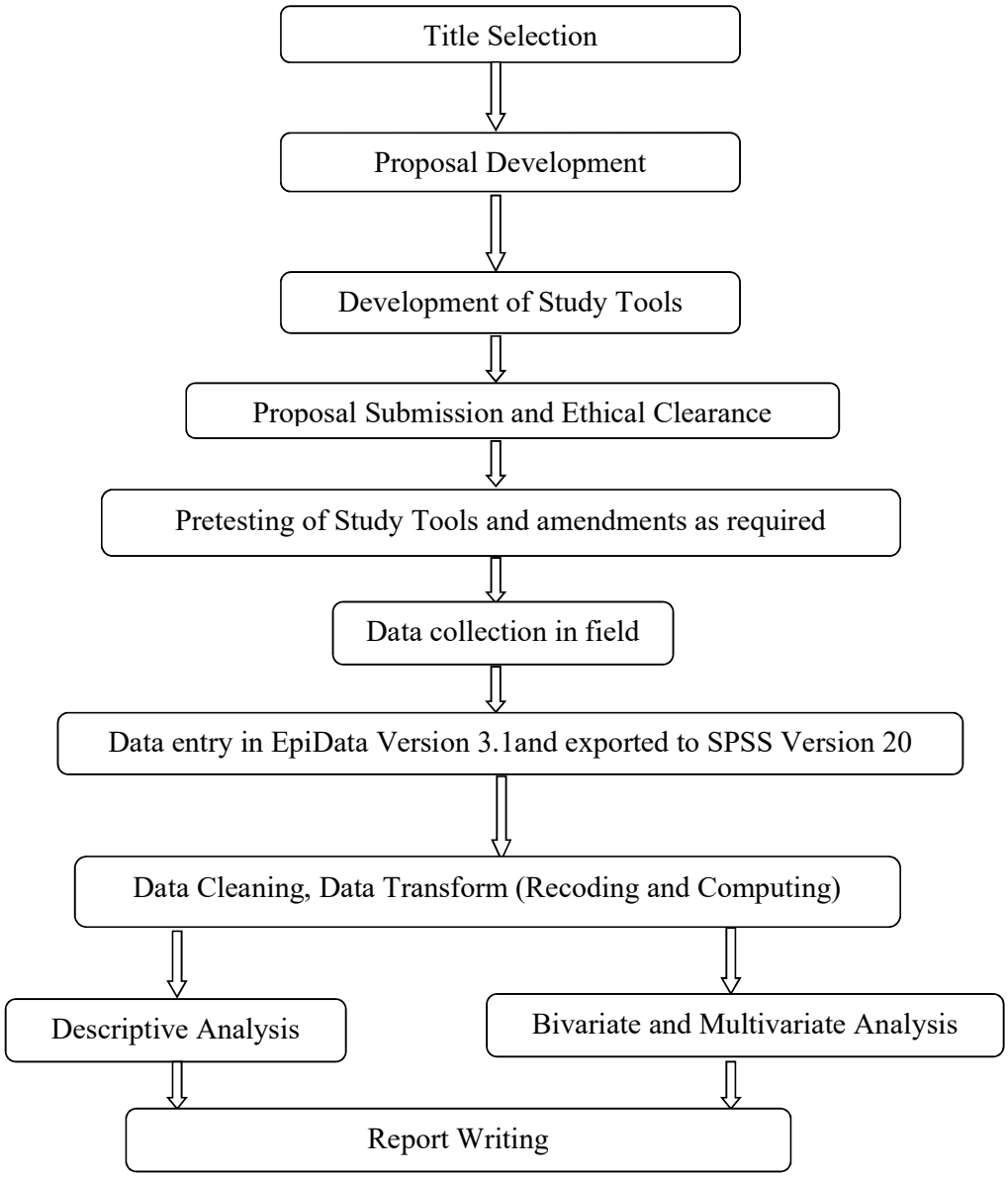


Figure 2: Study Process

3.4 Sample Size

The required sample size for detecting TB among people living with HIV was determined separately. All HIV-positive patients were screened using portable digital X-ray technology integrated with CAD4TB by trained healthcare workers at designated screening events. Sputum samples were collected from all presumptive TB cases and tested using the Gene-Xpert to confirm TB. All tests were conducted at the Provincial Diseases Control Center.

Sample size was calculated by using the following formula:

TB among HIV patients

$n= Z^2pq/d^2$

Where,

Z= value of standard normal distribution in 1.96 level of significant with 95% confidence level

p= 9.9% (Prevalence TB among HIV patients of Nepal is 9.9%) **(25)**

so the required p= 0.099

q = (1- p) = (1-0.099) = 0.901

d = desirable error 0.03 (3% margin of error)

Now putting the values,

n= $\frac{z^2pq}{d^2}$

n= $\frac{1.96^2 0.099*0.901}{0.003^2}$

n=137.04≈138

Assuming the Non response rate (NR) of 20% sample size,

Final sample size (n_2) = $\frac{n}{1-NR}$

$$\frac{138}{1-20/100}$$

= 172.5≈173

Required participants = 173

Design effects: 173*1.5= 259.5≈260

So the investigator aims to focus study by 260 samples following the calculation above.

3.5 Study Population

The study population was all the HIV/AIDS Patients who were registered under ART centers of Western Regional Hospital of Gandaki Province of Nepal.

3.6 Sampling Technique

Systematic random sampling method was adopted to reach the respondents in the study. A list of HIV patients from 2075 to 2082 was obtained from ART Register. The systematic random interval was calculated determining population size (1780) and sample size 260.

3.7 Study site and its justification

The study was conducted in the Gandaki province of Nepal. The highest number of HIV Patients (1780) were enrolled in the Western Regional Hospital ART center of Gandaki Province of Nepal in 2024 (Annual Report of Gandaki province, 2080/81).

3.8 Inclusion Criteria

- All the HIV/AIDS patients registered under the Western Regional Hospital ART center and who had completed 60 days under ART medication, respectively ART of Gandaki province.
- HIV/AIDS patients who were above 18 years of age.

3.9 Exclusion Criteria

- Those HIV/AIDS patients who were not present at the time of data collection, who disagreed to participate in the study and those with any kind of physical deformities were excluded from the study.

3.10 Data Collection Technique

Data was collected by face-to-face interview methods with the help of the interview schedule. Data were gathered in the prescribed format on the socio-demographic characteristics, disease conditions, behavioral and other factors associated with TB. At first all 260 participants were screened for TB using portable digital chest X-ray machine. Among them, sputum was collected from 37 participants with an abnormal or suspected chest X-ray for Gene-Xpert testing to diagnose TB. Only six participants were found to be pulmonary Tuberculosis cases and one was Pulmonary clinically diagnosed cases while 30 participants were found to be negative for *Mycobacterium Tuberculosis* based on Gene-Xpert testing. All seven diagnosed TB cases were enrolled for Directly Observed Treatment Short Course (DOTS) for Tuberculosis.

3.11 Data Collection Tool

The standard diagnostic guidelines were used for the diagnosis of Tuberculosis among HIV patients. The questionnaire developed was pretested prior of implementation. Appropriate suggestion was taken from the expert during the preparation of the tools and guidelines.

3.12 Data management and analysis

Socio-demographics data, clinical and laboratory data, lifestyle-related, environment related, nutrition-related data were entered into an Epi-Data database validated and

analyzed. Univariate and multivariate analyses using Poisson and binary logistic regression models was done to identify factors associated with TB among HIV patients. The factors identified as significant (p=0.05) on Univariate analysis were entered into the multivariate logistic regression models. Data analysis, including multivariate logistic regression models, sensitivity and specificity of portable digital X-ray technology integrated with CAD4TB vs Gene-Xpert was conducted with SPSS.

3.13 Ethical Considerations

Ethical approval was obtained from the IRC, PU (105/2082/83) . Administrative permission was taken from the PCDC. All participants were fully informed regarding study objectives, procedures, voluntary participation and their right to withdraw at any time. Written informed consent was obtained before the initiation of the data collection. Confidentiality was strictly maintained throughout the study. All data was stored in the computer database that was accessible only to the researcher with password protection and only share with the research team. All data were used solely for research purposes. Personal identifiers were de-identified to protect participant anonymity.

3.14 Dissemination of Finding

Dissemination of findings will be done using different channels either printed or online. One set of hard copies and soft copy will be submitted to the IRC, PU and required set of hard copies and soft copy will be submitted to NHRC. The findings from this study will be presented through oral or poster presentation in national and international workshops, seminar and conferences if applicable in future days. Scientific dissemination will be done through participating in national conference and publish research paper in peer or rank journal.

CHAPTER IV: RESULTS

Socio-demographic Characteristics

The findings of the study showed that nearly half of the participants i.e. 46.2% belonged to age group less than 45 years while 29.25% and 24.6% were aged 45-55 years and 55 years respectively. Majority (58.5%) of participants were found to be female followed by 41.5% as female participants. Likewise, majority of participants i.e. 75.4% belonged to Hinduism religion followed 18.8%, 5% and 0.8% of participants belonging to Buddhism, Christianity and Islam respectively. Regarding ethnicity, majority of participants belonged to relatively advantaged janajati (32.7%) and upper caste groups (22.3%). However, 18%, 15%, 10% and 1.2% were belonging to Dalit, religious minorities, disadvantaged Janajati and disadvantaged non-Dalit Terai caste respectively. Likewise, more than half of the participants (63.8%) were found to be married followed by 1.26% single and 13.8% widowed respectively. Similarly, the majority of participants resided in urban areas (75%) followed by rural areas (25%). Most of the participants (84.6%) were from nuclear families.

Table 1: Socio-demographic characteristics of the participants

Characteristics	Frequency (n=260)	Percentage (%)
Age		
<45 Years	120	46.2
45-55 Years	76	29.2
>55 Years	64	24.6
Gender		
Male	108	41.5
Female	152	58.5
Religion		
Hinduism	196	75.4
Buddhism	49	18.8
Christianity	13	5.0
Islam	2	0.8
Ethnicity		
Dalit	49	18.8
Disadvantaged Non-Dalit Terai Caste	3	1.2
Disadvantaged Janjati	26	10.0

Religious Minorities	39	15.0
Upper Caste Groups	58	22.3
Relatively Advantaged Janajati	85	32.7
Marital Status		
Single	42	16.2
Married	166	63.8
Divorced	14	5.4
Widowed	36	13.8
Separated	2	0.8
Permanent Residence		
Urban	195	75.0
Rural	65	25.0
Family Type		
Nuclear	220	84.6
Joint	40	15.4

The majority of study participants i.e. 43.5% had completed only basic education (1–8 class), followed by secondary education (25%), non-formal education (14.2%), and higher education (5.8%). Still, 11.5% of participants were found to be illiterate. Majority of participants i.e. 28.1% were found to be unemployed followed by business (19.2%), labor (10.8%), agriculture (8.8%), and housekeeping (9.6%). More than half of participants i.e. 66.2% and 55.85% were having personal monthly income less than NRs 27000 and family monthly income less than NRs30000 respectively. Likewise, more than third-fourth of participants (i.e. 79.6%) were found to be enrolled in national health insurance program.

Table 2: Socio-economic characteristics of the participants

Characteristics	**Frequency (n=260)**	**Percentage**
Educational Status		
Illiterate	30	11.5
Non-Formal Education	37	14.2
Basic Education (1-8 Class)	113	43.5
Secondary Education (9-12 Class)	65	25.0

Higher Education (Completion of Bachelor or Above)	15	5.8
Occupation		
Unemployed	73	28.1
Private Employee	18	6.9
Business	50	19.2
Housekeeper	25	9.6
Labor	28	10.8
Agriculture	23	8.8
Driver	9	3.5
Government Job	7	2.7
Others (Students, retirement)	27	10.4
Personal Monthly Income (N=145)		
<NRs 27000	96	66.2
≥NRs27000	49	33.8
Family Monthly Income (N=208)		
<NRs30000	116	55.8
≥NRs30000	92	44.2
Enrolment in Health Insurance Scheme		
No	53	20.4
Yes	207	79.6

Anthropometric assessment of HIV infected

The anthropometric assessment of HIV infected was done by computing body mass index of each participants. The findings showed that majority of participants (60.8%) had normal body mass index (BMI: 19–24.9 kg/m²) followed by 20.4% as overweight (BMI: 25–29.9 kg/m²) and 15.8% as underweight (BMI <19 kg/m²). Also, 3.1% of HIV infected people were found to be obese (BMI 30–34.9 kg/m²).

Table 3: Anthropometric related findings of HIV respondents

Characteristics	Frequency (n)	Percentage (%)
Body mass index group (kg/m2)		
Underweight (<19)	41	15.8
Normal (19-24.9)	158	60.8

Overweight (25-29.9)	53	20.4
Obesity (30-34.9)	8	3.1

Table 4: Tuberculosis related findings of people living with HIV/AIDS

Characteristics	Frequency (n)	Percentage (%)
Digital X-Ray With AI (N=260)		
Code-0: Normal	223	85.8
Code-1: Active TB, Probable (typical lesions such as infiltrate, cavity)	26	10.0
Code-2: Active TB, Possible (difficult to distinguish active or inactive)	7	2.7
Code-3: Old TB (fibrotic change, calcified nodules)	4	1.5
Gene-Xpert Report (Total tested sample, n=37)		
MTB Not Detected	30	81.1
MTB Detected	3	8.1
MTB Detected Very Low	1	2.7
MTB Detected Medium	2	5.4
Error/No Result	1	2.7
Clinical TB Diagnosed (n=4)		
PCD	1	25.0
Non-PCD	3	75.0
TB Status among people living with HIV/AIDS (n=260)		
Normal	253	97.30
PBC (Pulmonary Bacteriologically Confirmed)	6	2.31
PCD (Pulmonary Clinically Diagnosed)	1	0.38
Prevalence of TB among people living with HIV/AIDS (n=260)		
Normal	253	97.31
TB Diagnosed	7	2.69
Gene-Xpert Positivity Rate of TB Diagnosed (n=37)		
Negative	30	81.08
Positive	7	18.92

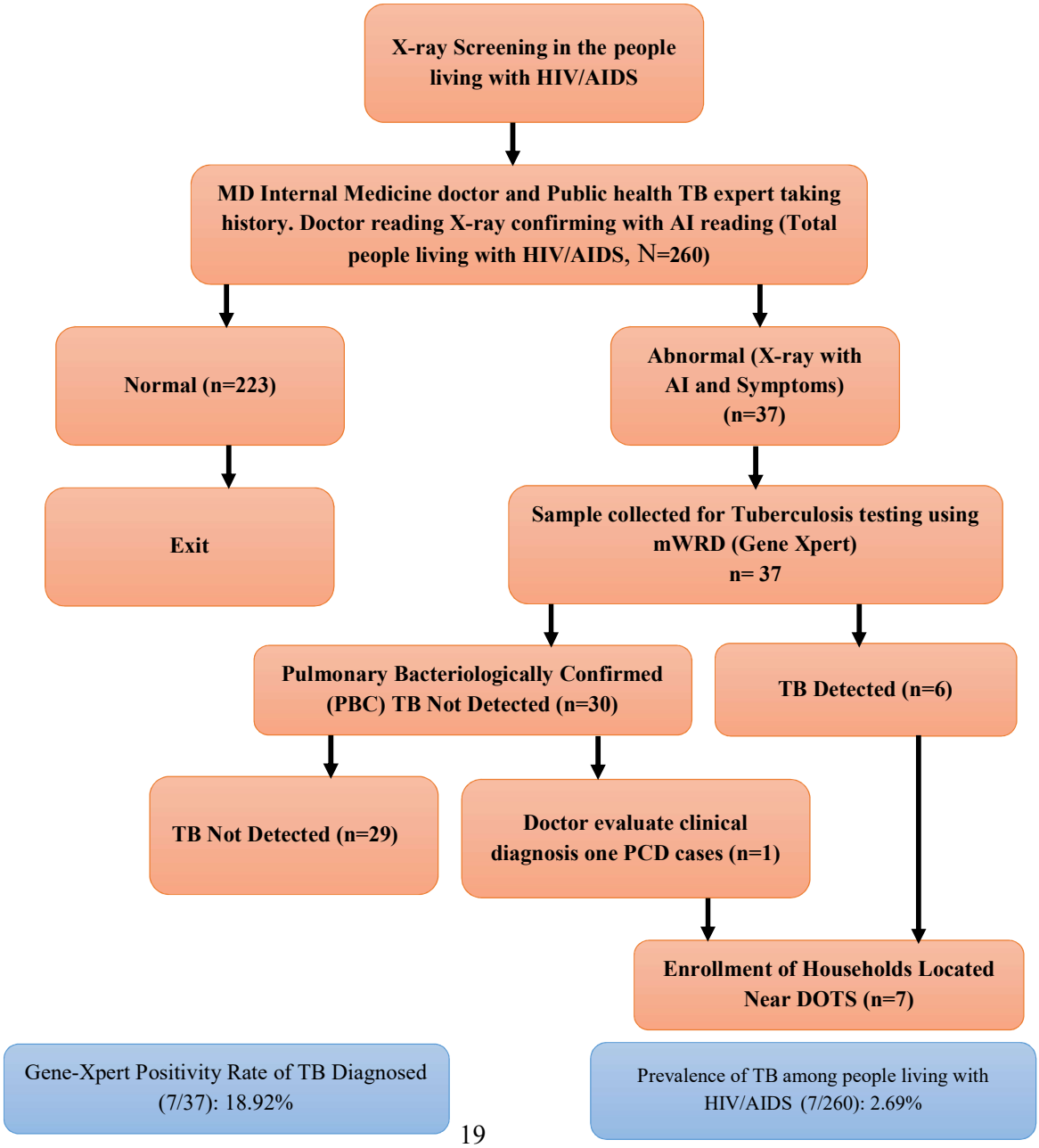
In this study, among the 260 people living with HIV/AIDS, digital chest X-ray screening was found to be normal among 85.8% of participants, while 14.2% of participants were

suggestive of active or old tuberculosis (TB). Among this, 10% were found to have active probable TB with typical lesions, 2.7% were active possible TB whereas 1.5% were found to be old TB cases. The Gene-Xpert test was performed among 37 participants. Of these, 81.1% (n=30) tested negative for *Mycobacterium tuberculosis* (MTB), while 16.2% (n=6) tested positive. Among the positive cases, MTB was detected in 8.1% of participants with high bacterial load, 5.4% with medium bacterial load, and 2.7% with very low bacterial load. Additionally, 2.7% of Gene-Xpert tests resulted in technical errors. Among the four clinically diagnosed TB cases, three were non-Pulmonary Clinically Diagnosed cases and one was PCD. Among the total participants, only seven were diagnosed with TB resulted in a TB prevalence of 2.7% in the study population comprising of six pulmonary bacteriologically confirmed (PBC) cases and one pulmonary clinically diagnosed (PCD) case. Likewise, the findings showed 18.92% as a Gene-Xpert positivity rate of TB diagnosed population.

Flow diagram of the TB diagnosis using X-ray with AI

The flow diagram presents the stepwise TB screening and diagnostic pathway among 260 people living with HIV/AIDS using AI-assisted chest X-ray. Of the total participants, 223 (85.8%) were classified as normal and excluded from further testing, while 37 (14.2%) showed abnormal X-ray findings with symptoms and were referred for Gene-Xpert testing. Among those tested using Gene-Xpert, 30 (81.1%) were negative for *Mycobacterium tuberculosis* whereas 7 (18.9%) were positive, including bacteriologically confirmed (n=6) and clinically diagnosed PCD cases (n=1). All confirmed TB cases were enrolled for DOTS-based management. This study found the TB prevalence as 2.69% (7/260).

Figure 1: Flowchart of the TB Diagnosis Using X-Ray with AI among people living with HIV/AIDS



Lifestyle related factors of HIV infected

The findings relating to current and prior lifestyle factors of HIV infected is tabulated below in Table 5. The findings revealed reduction in risky behaviors such as alcohol consumption, smoking habit and injecting drugs. The practice of alcohol consumption and smoking was found to be reduced in current time from 38.5% to 29.6% and 36.5% to 29.2% respectively after getting infected with HIV. Likewise, the practice of injecting drugs reduced to 3.8% from 10% among HIV infection.

Table 5: Life Style Related Factors of people living with HIV/AIDS

Characteristics	Prior		Current	
	Frequency(n)	Percentage	Frequency(n)	Percentage
Alcohol Consumption				
No	160	61.5	183	70.4
Yes	100	38.5	77	29.6
Smoking Habit				
No	165	63.5	184	70.8
Yes	95	36.5	76	29.2
Injecting Drug				
No	234	90.0	250	96.2
Yes	26	10.0	10	3.8

Risk factors of HIV infected

The findings relating to risk factors associated with HIV infection was tabulated in Table 6. This finding showed that about one-third (30%) of participants reported engaging in high-risk behaviours. Likewise, 31.9% of participants were found to be spouse of migrant labour workers.

Table 6: Risk Factors of people living with HIV/AIDS

Characteristics	Frequency	Percentage
High-risk behaviour Practices		
No	236	70.0
Yes	101	30.0
Spouse of Migrant labour worker		
No	177	68.1
Yes	83	31.9

Stigma and Discrimination of people living with HIV/AIDS

The stigma and discrimination related factors among HIV infected people has been tabulated in table 7. It was found that more than half of participants (i.e. 56.1%) had not disclosed their HIV status, while 43.1% had openly disclosed it. Likewise, almost half of the participants (49.2%) were found to be experiencing stigma and 50.8% not facing stigma related to HIV/AIDS. Similarly, more than half 50.8% of participants reported the negative family reactions upon disclosure of their HIV/AIDS status.

Table 7: Stigma and Discrimination of people living with HIV/AIDS

Characteristics	Frequency (n)	Percentage
Disclosed HIV Status		
No	148	56.1
Yes	112	43.1
Facing Stigma		
No	132	50.8
Yes	128	49.2
Family Reaction to HIV Status		
Negative Reaction	132	50.8
Positive Reaction	128	49.2

Disease related factors of HIV infected

The diseases related factors of HIV infected has been tabulated in Table 8. It showed that almost half of the participants i.e. 48.8% were living with HIV infection for more than 14 years. Among these, 53.1% of participants had been on treatment of their HIV status for

more than 12 years whereas 46.9% of participants were under treatment for less than 12 years. One-fourth of the participants (i.e. 25.8%) reported no side effects of drugs while still 25.8% of participants were facing side effects of drugs. Likewise, 76.9% of participants were found to have knowledge regarding transmission of HIV. Among them, 76.4%, 63.8%, 55.8% and 44.7% of participants reported multiple sexual partners, unsafe sexual contact, unsafe use of injection and blood transfusion as routes of HIV transmission. More than half i.e. 66.5% had a viral load of <50 copies/mL whereas one-third (33.5%) had viral load ranging from 50 to 10,000 copies/mL. The majority (76.9%) of participants had no family history of diabetes. Among those with a family history of diabetes, 61.7% and 26.7% reported that father and mother was diagnosed with diabetes respectively.

Table 8: Disease Related Factors of People living with HIV/AIDS

Characteristics	Frequency (n)	Percentage
Duration of living with HIV infection		
<14 Years	133	51.2
≥ 14 Years	127	48.8
Duration of Treatment		
<12 Years	122	46.9
≥ 12 Years	138	53.1
Side effects of drug		
No	193	74.2
Yes	67	25.8
Know about the transmission of HIV		
No	60	23.1
Yes	200	76.9
HIV Transmission **(Multiple Response)		
Unsafe use of injection	111	55.8
Unsafe sexual contact with HIV infected person	127	63.8
Multiple sexual partners	152	76.4
Blood Transfusion	89	44.7
Viral load Status		
<50 copies/mL	153	66.5
≥50-10,000 copies/mL	77	33.5
Family History of Diabetes		

No	200	76.9
Yes	60	23.1
If yes, Who in your family has been diagnosed?		
Father	37	61.7
Mother	16	26.7
Wife	3	5.0
Grand Father	2	3.3
Mother in law	2	3.3

Prevalence of comorbidities and type of comorbidities

The findings demonstrated that 42.3% of people living with HIV/AIDS had comorbidities. Among them, 34.5%, 30%, 18.2% and 8.23% of participants had hypertension, tuberculosis, diabetes and CVD respectively followed by Hepatitis B and kidney disease. Majority of participants i.e. 78.8% had no prior treatment while 21.2% had prior treatment for tuberculosis. Among those receiving the treatment, 81.8% were pulmonary TB followed by 12.7% as PCD cases and 5.5% as extra-pulmonary TB cases. Likewise, majority (i.e. 88.5%) of participants reported no recent close contact with TB patients while 11.5% were recently in close contact with TB infected. Moreover, more than three-fourth of participants (78.1%) reported not having symptoms resembling with TB while 21.9% reported symptoms resembling with TB. Among those, the most frequently reported symptoms were found to be chest pain (83.6%) followed by cough expectoration (32.7%), weight loss (32.7%), low grade fever (27.3%), loss of appetite (23.6%) and blood in sputum (10.9%) respectively.

Table 9: Prevalence and type of comorbidities among People living with HIV/AIDS

Characteristics	Frequency (n)	Percentage
Prevalence of Comorbidities		
No	150	57.7
Yes	110	42.3
Types of Co-morbidities(Multiple Response)**		
Hypertension	38	34.5
TB	33	30.0
Diabetes	20	18.2
CVD	9	8.23
Hepatitis B	8	7.3

Kidney	7	6.4
Thyroid	5	4.5
Liver	5	4.5
Cholesterol	3	2.7
Cancer	3	2.7
Hepatitis C	1	0.9
Received any TB treatment before		
No	205	78.8
Yes	55	21.2
Types of TB		
PBC	45	81.8
PCD	7	12.7
EP	3	5.5
Recent close contact with a TB patient		
No	230	88.5
Yes	30	11.5
Symptoms resembled with tuberculosis		
No	203	78.1
Yes	57	21.9
TB Symptoms **(Multiple Response)		
Cough with expectoration	18	32.7
Chest Pain	46	83.6
Low grade fever	15	27.3
Blood in Sputum	6	10.9
Loss of appetite	13	23.6
Loss of weight	18	32.7

Bivariate analysis with socio-demographic characteristics

The bivariate analysis done to determine the factors associated with presence of Tuberculosis among people living with HIV/AIDS. The findings showed that sex and ethnicity of participants were significantly associated with the presence of TB. It was found that male participants living with HIV/AIDS 8.88 times (95% CI: 1.054-74.883, p=0.022) higher odds of getting TB compared with females. Similarly, participants from the Dalit

ethnic group had 9.91 times (95% CI: 1.007-97.605, p=0.049) higher odds of getting TB compared with those from relatively advantaged Janajati and other caste groups. The association was found to be statistically significant. Likewise, it was found that non-Hindu participants living with HIV/AIDS were 1.23 times (95% CI: 0.233-6.511, p=0.682) higher odds of getting TB compared with Hindus. The people with HIV infection living in nuclear family has 2.310 times (95% CI: 0.503-10.608, p=0.294) higher odds of getting TB. However, these associations were not statistically significant. The presence of tuberculosis has no significant associations with other socio-economic characteristics such as age, marital status, place of residence, education level, occupation, monthly income, or enrollment in a health insurance scheme.

Table 10: Association between Socio-demographic and economic characteristics among People living with HIV/AIDS

Characteristics	Presence of TB		p-value	UOR	95%CI
	No n (%)	Yes n (%)			
Sex					
Male	104 (94.4)	6 (5.6)	0.022*	8.882	1.054-74.883
Female	151 (99.3)	1 (0.4)		**1**	**Ref**
Age					
<55 Years	191 (97.4)	5 (2.6)	0.548	**1**	**Ref**
≥55 Years	62 (96.9)	2 (3.1)		0.812	0.154-4.288
Religions					
Hinduism	191 (97.4)	5 (2.6)	0.682	**1**	**Ref**
Non-Hinduism	62 (96.9)	2 (3.1)		1.232	0.233-6.511
Ethnicity					
Dalit	46 (93.9)	3 (6.1)	0.049*	9.913	1.007-97.605
Upper Caste Group	55 (94.8)	3 (5.2)	0.070	8.291	0.845-81.390
Relatively Advantaged Janajati and Others caste	152 (99.3)	1 (0.7)		**1**	**Ref**
Marita Status					
Single/Unmarried	92 (97.9)	2 (2.1)	0.505	**1**	**Ref**
Married	161 (97.0)	5 (3.0)		1.429	0.272-7.511
Place of Residence					

Urban	191 (97.9)	4 (2.1)	0.371	**1**	**Ref**
Rural	62 (95.4)	3 (4.6)		2.734	1.265-8.972
Types of Family					
Nuclear	215 (97.7)	5 (2.3)	0.294	**1**	**Ref**
Joint	38 (95.0)	2 (5.0)		2.310	0.503-10.608
Education Level					
Illiterate/Non-formal	63 (94.0)	4 (6.0)		4.021	0.876-18.456
Basic and Above Education	190 (98.4)	3 (1.6)	0.075	**1**	**Ref**
Occupation					
Unemployed	83 (98.8)	1 (1.2)	0.434	**1**	**Ref**
Employed	170 (96.6)	6 (3.4)		2.929	0.347-24.730
Personal Monthly Income (N=99)					
<NRs 27000	92 (95.8)	4 (4.2)	0.673	1.022	0.181-5.783
≥NRs27000	47 (95.9)	2 (4.1)		**1**	**Ref**
Enrolment in Health Insurance Scheme					
No	51 (96.2)	2 (3.8)	0.589	1.584	0.299-8.402
Yes	202 (97.6)	5 (2.4)		**1**	**Ref**

** Statistically significant., Fisher"s Exact Test*

Bivariate analysis with lifestyle related risk factors

The bivariate analysis was done to assess the association of lifestyle related factors and presence of TB among people living with HIV/AIDS in Nepal. The higher odds of getting TB was revealed among participants with current alcohol use, smoking history, current smoking, history of injecting drug use, and current injecting drug use. Among all the behavioral related variables, only history of alcohol consumption was found to be significantly associated with the presence of TB. The participants with a history of alcohol use were found to be 10 times (95% CI: 1.203-85.599, p=0.014) more likely to have TB compared with those without such a history of alcoholic consumption. Likewise, participants with current alcohol use were found to be 3.28 times (95% CI: 0.718-15.054, p=0.201) more likely to have TB compared with those without current alcoholic consumption practices. The participants with smoking history and current smoking practices were found to be 4.52 times (95% CI: 0.861-23.811, p=0.075) and 3.352 times (95% CI: 0.732-15.351, p= 0.199) more likely to have TB compared with those without history and current smoking habits

respectively. Similarly, the participants with history and current drug injecting practices were found to be 3.81 times (95% CI: 0.702-20.744, p=0.148) and 4.51 times (95% CI: 0.491-41.565, p= 0.183) more likely to have TB compared with those without history and current drug injecting habits respectively. However, these associations were not found to be statistically significant.

Table 11: Association between lifestyle-related characteristics among people living with HIV/AIDS

Characteristics	Presence of TB		p-value	UOR	95%CI
	No n (%)	Yes n (%)			
Alcoholic History					
No	159 (99.4)	1 (0.6)	0.014*	**1**	**Ref**
Yes	94 (94.0)	6 (6.0)		10.149	1.203-85.599
Current Alcohol Use					
No	180 (98.4)	3 (1.6)	0.201	**1**	**Ref**
Yes	73 (94.8)	4 (5.2)		3.288	0.718-15.054
Smoking History					
No	163 (98.8)	2 (1.2)	0.075	**1**	**Ref**
Yes	90 (94.7)	5 (5.3)		4.528	0.861-23.811
Current Smoking					
No	181 (98.4)	3 (1.6)	0.199	**1**	**Ref**
Yes	72 (94.7)	4 (5.3)		3.352	0.732-15.351
Injecting Drug History					
No	229 (97.9)	5 (2.1)	0.148	**1**	**Ref**
Yes	24 (92.3)	2 (7.7)		3.817	0.702-20.744
Current Injecting Drug					
No	244 (97.6)	6 (2.4)	0.183	**1**	**Ref**
Yes	9 (90.0)	1 (10.0)		4.519	0.491-41.565

Bivariate analysis with stigma and discrimination related characteristics

The bivariate analysis was done to assess the association of stigma and discrimination related factors and presence of TB among people living with HIV/AIDS in Nepal. There was no statistically significant association between TB status and HIV/AIDS disclosure

status or social stigma and discrimination. The findings showed that participants who had not disclosed their HIV status had 1.92 times (95% CI: 0.366-10.099, p=0.702) higher odds of getting TB as compared to those who had disclosed. Similarly, participants who reported experiencing social stigma and discrimination had 2.64 times (95% CI: 0.503-13.872, p=0.276) higher odds of getting TB. However, the association was not found to be statistically significant.

Table 12: Association between Stigma and Discrimination related characteristics among People living with HIV/AIDS

Characteristics	Presence of TB		P-value	UOR	95%CI
	No n (%)	Yes n (%)			
Disclosed of HIV					
No	143 (96.6)	5 (3.4)	0.702	1.923	0.366-10.099
Yes	110 (98.2)	2 (1.8)		**1**	**Ref**
Social Sigma and Discrimination					
No	130 (98.5)	2 (1.5)	0.276	**1**	**Ref**
Yes	123 (96.1)	5 (3.9)		2.642	0.503-13.872

Bivariate analysis with diseases related characteristics

The bivariate analysis of diseases related characteristics with TB status showed that comorbidities, higher viral load, close contact with TB patients and presence of TB symptoms were significantly associated with TB status. Participants with comorbidities were found to be 8.59 times (95% CI: 1.020-72.463, p=0.024) more likely of getting TB as compared to their counter parts. Also, HIV infected people with viral load >200 copies/mL had 12.85 higher (95% CI: 1.518-108.704, p=0.006) odds of getting TB as compared to those with viral load <50 copies/mL. Similarly, participants having close contact with TB patients and presence of TB symptoms had 6.28 times (95% CI: 1.333-29.555, p=0.035) and 9.66 times (95% CI: 1.823-51.228, p=0.006) higher odds of getting TB as compared to their counterparts respectively. However, BMI status, family history of HIV, duration of ART treatment, and drug side effects were not significantly associated with TB presence. The participants with family history of HIV had 1.02 times (95% CI: 0.224-4.668, p=0.631) higher chances of getting TB as compared to those without family history of HIV. Likewise, participants having side effects of drug were found to be 1.15 times (95% CI: 0.219-6.108, p=0.577) higher odds of getting TB as compared to those not having side effects. These associations were not statistically significant.

Table 13: Association between diseases related characteristics among People living with HIV/AIDS

Characteristics	Presence of TB		p-value	UOR	95%CI
	No n (%)	Yes n (%)			
BMI (kg/m2)					
Underweight	40 (97.6)	1 (2.4)	0.695	**1**	**Ref**
Normal weight	213 (97.3)	6 (2.7)		1.127	0.132-9.613
Family history of HIV					
No	107 (97.3)	3 (2.7)	0.631	**1**	**Ref**
Yes	146 (97.3)	4 (2.7)		1.023	0.224-4.668
ART Enrollment					
<12 Years	118 (96.7)	4 (3.3)	0.709	1.525	0.335-6.955
>12 Years	135 (97.8)	3 (2.2)		**1**	**Ref**
Side Effects of Drug					
No	188 (97.4)	5 (2.6)	0.577	**1**	**Ref**
Yes	65 (97.0)	2 (3.0)		1.157	0.219-6.108
Comorbidities					
No	149 (99.3)	1 (0.7)	0.024*	**1**	**Ref**
Yes	104 (94.5)	6 (5.5)		8.596	1.020-72.463
Viral Load Value					
<50 copies/mL	152 (100.0)	1 (0.0)	0.006**	**1**	**Ref**
>200	71 (91.0)	7 (9.0)		12.845	1.518-108.704
Close contact with TB Patients					
No	226 (98.3)	4 (1.7)	0.035*	**1**	**Ref**
Yes	27 (90.0)	3 (10.0)		6.278	1.333-29.555
Symptoms of TB					
No	201 (99.0)	2 (1.0)	0.006*	**1**	**Ref**
Yes	52 (91.2)	5 (8.8)		9.663	1.823-51.228

** Statistically significant.*

Final multivariate regression analysis

In multivariable analysis, ethnicity was the only factor significantly associated with presence of TB among people living with HIV/AIDS**.** The findings showed that participants from the Dalit group were 19.92 times (95% CI: 1.172-338.689, p=0.038) more likely of getting TB compared to the reference group i.e. relatively advantaged janajati and other caste while adjusting for other factors. The other independent variables such as sex, alcohol history, comorbidities, viral load, close contact with TB patients, and TB symptoms demonstrated higher or lower odds of getting TB compared to their counterparts. Likewise, male participants and having alcoholic history were 4.44 times (95% CI: 0.365-54.117, p= 0.242) and 4.74 times (95% CI: 0.352-64.020, p=0.241) higher chances of getting infected with TB as compared to female and those without alcoholic history while controlling for other factors. The participants with symptoms of TB were 5.13 times (95% CI: 0.518-50.814, p=0.162) more likely to have TB infection as compared to those without any symptoms. Similarly, the participants with close contacts with TB infected were 4.061 times (95% CI: 0.505-32.633, p=0.188) more likely to have TB infection as compared to those without having close contacts. However, the association were not statistically significant. This showed that after adjustment ethnicity remained the only independent predictor of TB.

Table 14: Adjusted relationship of explanatory variables with People living with HIV/AIDS

Characteristics	P-value	AOU	95%, CI
Sex			
Male	0.242	4.441	0.365-54.117
Female		**1**	**Ref**
Ethnicity	0.113		
Dalit	0.038*	19.921	1.172-338.689
Upper Caste Group	0.134	7.444	0.538-103.043
Relatively Advantaged Janajati and Others caste		**1**	**Ref**
Alcoholic History			
No	0.241	**1**	**Ref**
Yes		4.744	0.352-64.020

Comorbidities			
No	0.650	**1**	**Ref**
Yes		1.932	0.113-33.120
Viral Load Value			
<50 copies/mL	0.240	**1**	**Ref**
>50 copies/mL		4.251	0.380-47.489
Close contact with TB Patients			
No	0.188	**1**	**Ref**
Yes		4.061	0.505-32.633
Symptoms of TB			
No	0.162	**1**	**Ref**
Yes		5.132	0.518-50.814

***** *Statistically significant.*

CHAPTER V: DISCUSSION

Socio-demographic characteristics

This study assessed socio-demographic, clinical, lifestyle, and disease-related factors associated with tuberculosis (TB) among 260 people living with HIV/AIDS (PLHIV) in Gandaki province of Nepal, using AI-assisted chest X-ray screening followed by Gene-Xpert testing. The high prevalence of TB in Nepal clearly highlights the need of active case findings to ensure the effectiveness of TB screening at community level. With innovation of AI enhanced X rays there has been modifications in screening criteria for testing TB. The AI assisted chest X-ray classified as abnormal was further referred for further testing in Gene-Xpert. This study showed the overall TB prevalence among PLHIV was obtained as 2.69% with six bacteriologically confirmed pulmonary TB (PBC) cases and one pulmonary clinically diagnosed (PCD) case based on this flow diagram. This finding is higher than reported by the study done in prison using chest X-ray revealing 0.8% as positivity rate of TB with 6 bacteriologically confirmed and 6 clinically diagnosed cases. Active Tuberculosis Case Finding Using Digital Chest X-ray with Artificial Intelligence in Prisons of Nepal: An Initial Experience. This finding is in contrast with another study which revealed 9.9% (20) and 13.7% (26) as a prevalence of TB among PLHIVs. This might be due to variations in study area and diagnostic mechanisms.

Factors associated with TB infection among PLHIV

The findings showed that sex and ethnicity of participants were significantly associated with the presence of TB which is similar with the findings from another study which showed higher TB prevalence among female and Dalit ethnic group (20). Another study conducted in India also revealed males have higher risk of developing TB (26). This might be due to existing socio-economic inequalities of Nepalese society. This study does not revealed significant association of age with TB among PLHIV which is similar with study done in India (26). This study assessed the risk of developing TB among PLHIVs based on different clinical characteristics which showed that comorbid condition, higher viral load, close contact with TB patients and presence of TB symptoms were significantly associated with TB status. Also, HIV infected people with viral load >200 copies/mL had higher odds of getting TB which is similar with findings from another study done in Nepal which revealed comparatively high TB among PLHIVs with CD4 cell count less than 200 cells/UL (20). Another study done in Burkina Faso identified CD4 cell counts below 200/µl as adjusted TB

risk factors (21). This might be due to the reason that CD4 count less than 200 implies that PLHIV developed AIDS which signifies that they are more prone to opportunities infections such as TB. Similarly, the history of and current drug injecting practices of participants were found to be 3.81 times (95% CI: 0.702-20.744, p=0.148) and 4.51 times (95% CI: 0.491-41.565, p= 0.183) more likely to have TB compared with those without history and current drug injecting habits respectively which is higher than the findings revealed by study done in Iran which determine that injecting drug use (OR= 1.46) increased the risk of TB and HIV coinfection ($p<0.05$) (19).

Moreover, BMI status, family history of HIV, duration of ART treatment, and drug side effects were not significantly associated with TB presence which is in contrast with findings demonstrating significantly higher risk of developing TB among those with family history (20). This finding is contrasting with study done in South West Ethiopia which demonstrated history of contact with tuberculosis patient in the family as independently associated with development of active tuberculosis (22). The study done in Ethiopia also revealed similar findings that BMI less than 18.5 kg/m2 and history of contact with a tuberculosis patient in the family (27). This findings is similar with study done in Lingwala health facilities demonstrating association of viral load, history of tuberculosis and BMI<18.5 kg/m2 with TB coinfection among PLHIV (28). The findings related to BMI status is in contrast with study done in Ethiopia which showed that a body mass index less than 18.5 kg/m2 (OR=4.1; 95% CI: 2.3, 7.4) is independently associated with the development of active tuberculosis in people living with HIV/AIDS (22).

CHAPTER VI: CONCLUSION

This study highlights the burden of tuberculosis (TB) among people living with HIV (PLHIV) and identifies several socio-demographic, lifestyle-related, behavioural-related and disease-related factors associated with TB case finding. Tuberculosis remains as an important comorbidity among PLHIV. The factors such as sex, ethnicity, alcoholic history, comorbidities, viral load (CD4 count), close contact with TB patient and symptoms resembling with TB were identified as major predictors for TB infection among PLHIV. However, ethnicity was identified as main factor associated TB during adjusted analysis. It signifies the need for equity-based TB/HIV interventions to address the social determinants of health in Nepalese society. Integrated screening services using AI in line with molecular testing must be prioritized for high risk people with HIV infection. These findings emphasized the need for routine and intensified active TB screening among PLHIV, particularly among high-risk groups, to facilitate early diagnosis and timely treatment using the advanced and portable technology. The findings suggest the TB screening among PLHIV in efficient manner by using digital Chest X-ray despite of molecular testing using Gene-Xpert among all PLHIV. These could be an important evidence for resource constraint setting like Nepal. The evidence generated by this study provides valuable guidance for policymakers, program managers, and healthcare providers in strengthening national HIV/TB control efforts in Nepal by updating the guidelines and policies based on research findings for early and efficient TB case finding among PLHIV.

Strengths and limitations of the study

The study combined AI-assisted radiography and molecular testing within ART clinic setting, used systematically collected clinical and behavioral data, and performed multivariable analysis to identify independent predictors of TB among people infected with HIV. The cross-sectional study design limits causal inference. The small number of TB diagnosis (n=7) reduces statistical power and yields wide confidence intervals, especially in adjusted models. Self-reported behavioral data may be affected by social desirability bias. Gene-Xpert testing was performed only for the subset with abnormal X-rays and symptoms; subclinical bacteriologic TB among those with normal X-rays could have been missed.

Recommendations

- AI-assisted chest X-ray followed by Gene-Xpert testing could be scaled up in HIV clinics to increase diagnostic efficiency and case detection while conserving laboratory resources.
- Use of portable digital X-ray prior molecular testing among PLHIV could be boon for low-middle-income countries like Nepal with resources constraint to scale up active screening of TB among PLHIV.
- PLHIV especially with comorbidities, having family history, close contact with TB patient's higher viral load and lower BMI must be prioritized for diagnosis, preventive and treatment services of TB.
- Integrating TB screening with digital technology, smoking/alcohol counseling and social support within HIV care can improve early detection and reduce onward transmission.

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ANNEX I: INFORMED CONSENT

Namaskar!

Aim for a research study on **"Leveraging Portable Digital X-Ray to Strengthen TB Case Finding among People Living with HIV in Gandaki Province of Nepal".** Please provide real information to my questions. The answers which you provide me are only used for research purposes. I assure you that we will maintain your privacy of information is each stage of research. I can only involve you after getting your consent and during the interview your freedom to quite from the interview if you feel discomfort to questions or other problems. For the interview session, it will take 10-15 minutes to collect the information. I hope you are willing to participate in this interview and Digital x-ray because your participation and your view are the most important for research and researcher.

Principle Investigator: Dr. Amar Nagila, Associate Professor, PAHS

Co-Principal Investigator: Dr. Sunil Raj Gautam, Dr. Yadunath Baral, Dr.Roshan Dhakal, Sushila Baral, Rajesh Kumar Yadav

Research Financial Supported by: Nepal Health Research Council (NHRC)

I agree in this research and interested to participate. Yes ☐ No ☐

Signature of Participant…… Signature of researcher ……

Date…… Date……

If illiterate

Thumb print of Participant

Left Thumb Right Thumb Signature of witness

……..

Date……

If you have any queries regarding this research please inform me at nagila2a@gmail.com and or directly you can call me on 9856036560

अनुसन्धान सुसुचित मञ्जुरीनामा फारम

नमस्कार !!! यो अध्ययनको उदेश्य “गण्डकी प्रदेशका एचआईभीसँग बाँचिरहेका व्यक्तिहरूमा क्षयरोग (टीबी)का केस पहिचानलाई प्रभावकारी रूपमा सुदृढ गर्न पोर्टेबल डिजिटल एक्स–रे प्रविधिको प्रयोगसम्बन्धमा ” तथ्याङ्क सकंलन गर्ने हो। यस अनुसन्धानले तपाईलाई व्यक्तिगत रुपमा कुनै पनि हानी नोक्सानी पुर्याउने छैन र यसमा सोधिएका प्रश्न वा कथन/वाक्यहरुको तपाईले निर्धक्क भई जवाफ दिन सक्नुहुनेछ किनकी ति जवाफहरु र दिएको खकार तपाई र अनुसन्धानकर्ता विच पूर्ण रुपमा गोप्य रहने छ। यस प्रश्नावलिका लागि १० देखि १५ मिनेट समय लाग्ने छ र यस क्रममा तपाई कुनै पनि बेला अनुसन्धान प्रकृयाबाट बाहिरिन खोजेमा तपाईको सम्मान गरिने छ तपाईलाई कुनै पनि अवस्थामा बाध्य पारीने छैन।

उपरोक्त व्यहोरा पढन समय दिनु भएकोमा धन्यवाद।
म यस अनुसन्धान प्रकृयामा सहभागी हुन तयार छु ☐ तयार छैन ☐

सहभागिको हस्ताक्षर ..... अध्ययनकर्ताको हस्ताक्षर .....
मिति: .....
अशिक्षित व्यक्तिको लागी
औठा को छाप साक्षी को हस्ताक्षर
.....
दायाँ बायाँ मिति: .....

यदि तपाईलाई यस अनुसन्धान सम्बन्धी कुनै जिज्ञासा भएमा यो nagila2a@gmail.com, rky0013@gmail.com ईमेल वा अथवा ९८५६०३६५६०/९८४६४२१६४३ मा फोन सम्पर्क गर्न सक्नुहुनेछ ।

हजुरको अमुल्य समयको लागि धन्यवाद !!!!

ANNEX II: QUESTIONNAIRE

Form ID No: …….. Gene-Xpert Report: ……

Section A: Socio-Demographic Characteristics

HIV Treatment Registration Number	
Date of Registration	
Treatment Centre	WRH-ART
Weight	……..Kg
Height	……Meter
BMI	……

S.N	Questions/Variables	Responses/Code	Skipping
A1	Date of birth	……./……/……(YYYY/MM/DD) …Years	
A2	Sex	1. Male 2. Female	
A3	Religion	1. Hinduism 2. Buddhism 3. Islam 4. Christianity 5. Others (Specify)	
A4	Ethnicity	1. Dalit 2. Disadvantaged Non-Dalit Terai Caste 3. Disadvantaged Janajati 4. Religious Minorities 5. Upper Caste Groups 6. Relatively Advantaged Janagati 7. Others (Specify)	
A5	Marital Status	1. Single 2. Married 3. Divorced 4. Widowed 5. Separated	
A6	Permanent Address (District/Palika)	…….	
A7	Current Address	1. Urban (M/SM/M) Rural (RM)	
A8	Type of Family ……..members	1. Nuclear 2. Joint	
A9	Educational level	1. Illiterate 2. Informal 3. Basic Education (1-8 class) 4. Secondary Education (9-12 class)	

		5. Higher Education (Completion of bachelor or above)	
A10	Occupation	1. Unemployed 2. Private Employee 3. Labor 4. House Keeper 5. Driver 6. Government Job 7. Business 8. Others (Specify)…..	
A11	Personal Monthly Income	…….NRs	
A12	Family Monthly Income	…….NRs	
A13	Enrollment Health Insurance status	**0. No 1.Yes**	

Section B: Life Style and Stigma Related Factors:

S.N	Questions/Variables	Responses/Code	Skip
B1	Alcoholic History	0. No 1. Regular User	
B2	Have you currently consumed any alcohol such as beer, wine, alcohol and homebrewed alcohol	0. No 1. Yes	**If No go to B3**
B3	Smoking History	0. No 1. Regular Smoking	
B4	Do you currently smoke any cigarettes or Pipes?	0. No 1. Yes	**If No go to B5**
B5	Injecting Drug History	0. No 1. Yes	
B6	Do you currently inject the drug	0. No 1. Yes	**If No go to B7**
B7	High-risk behaviour practices	0. No 1. Yes	
B8	Spouse of Migrant labor worker	0. No 1. Yes	
B9	Disclosed HIV Status	0. No 1. Yes	**If No go to B10**
	C1A. If No, Reason for not disclosing	1……. 2……. 3……	
B10	Facing stigma and discrimination	0. No 1. Yes	

B11	Family History of HIV/AIDS? ……who are	0. No 1. Yes	**If No go to C1**

Section C: Diseases Related Factors (According to base on Patients/HIV Register Card)

S.N	Questions/Variables	Responses/Code		Skip
D3	How long have you been HIV infection?	……Months		
D4	How long have you been enrolled in ART?	…….Months		
D5	Have you Experienced any side effects with HIV Medicine?	0. No 1. Yes (if yes, what is)……. ……		
D6	Do you know about the transmission of HIV?	0. No 1. Yes.		If NO go to D7
	D6A. How does HIV spread? **(Multiple Response)	1. Unsafe sexual contract with HIV infected person 2. Blood transfusion 3. Unsafe use of injection 4. Multiple sexual partners 5. Others (Specify)……		
D7	Have any diseases been diagnosed other than HIV?	0. No 1. Yes		If NO go to D8
	D7A. if yes, what is, Specify.....			
	Diseases	Duration of illness	Treatment Outcome	
	Hepatitis B	……Month	**0. No 1. Yes**	
	Hepatitis C	……Month	No 1. Yes	
	TB	……Month	No 1. Yes	
	CVD	……Month	No 1. Yes	
	Hypertension	……Month	No 1. Yes	
	Diabetes	……Month	No 1. Yes	
	Others ……	……Month	No 1. Yes	
	Others……	……Month	No 1. Yes	
D8	Current CD4 level/Viral Load	**……..**		
D9	Current WHO Stage	**1. Stage I** **2. Stage II** **3. Stage III**		
D10	Did you receive any TB treatment before?	0. No 1. Yes		**(if No, skip D11)**
	If yes	1.DS TB(PBC, PCD &EP) 2.DR TB		

D11	Have you been in close contact with someone diagnosed with tuberculosis recently?	0. No 1. Yes	
D12	Do you have any symptoms resembled with tuberculosis?	0. No 1. Yes	
	D12. A If yes, which symptoms do you have?	1. Cough with expectoration 2. Chest pain 3. Low grade fever 4. Blood in Sputum 5. Loss of appetite 6. Loss of weight **4. 7. Others (specify)**	
D13	Do any of your family members have a history of diabetes?	0. No 1. Yes	
	If yes, Who in your family has been diagnosed?		

Do you have any suggestions or feedback for HIV and TB program?

1. **…….**
2. **…….**

Thank You

ANNEX III: IRC LETTER

पोखरा विश्वविद्यालय
POKHARA UNIVERSITY
Kaski, Nepal

चलानी नं.:/Ref. No. 105/2082/83 2082/12/23

Dr. Amar Nagila
Principal Investigator
School of Health and Allied Sciences
Pokhara University

Ref: Ethical Approval of Research Proposal

Dear Dr. Nagila,
It is our pleasure to inform you that Institutional Review Committee (IRC), Pokhara University has approved your proposal as per the decision taken by the committee on 22/12/2082, Meeting number 96.

Research Title: **Leveraging Portable Digital X-Ray to Strengthen TB Case Finding among People Living with HIV in Gandaki Provice of Nepal**

As per NHRC and PU-IRC rules and regulations, the investigator has to strictly follow the protocol mentioned in the proposal. Any change in objective(s), problem statement, research question, hypothesis, methodology, implementation procedure, data management and budget needed during the implementation of this research proposal can only be made after prior approval from PU-IRC. It is mandatory to submit the details of intended changes with justification to PU-IRC for approval.

Further, the researchers are informed to strictly abide by the NHRC and PU-IRC regulations during the implementation of their research protocol and submit progress report and final report upon completion.

If you have any question, please feel free to contact the IRC, Pokhara University.

Thank You!

.....
Dr. Suresh Jaiswal
Chairperson
Institutional Review Committee
Pokhara University
Email: puirc@pu.edu.np

गण्डकी प्रदेश सरकार
स्वास्थ्य मन्त्रालय
प्रादेशिक क्षयरोग नियन्त्रण केन्द्र
गण्डकी प्रदेश, पोखरा, नेपाल

फान न. ०६१-५७१०६३
०६१-५७१०६४
०६१-५७१०६५
०६१-५७१६२०
फयाक्स: ०६१-५७१०६४
Email:rtcpkr@gmail.com

प.स: २०८२/०८३
च.नं ४१

मिति:२०८२/०६/२८ गते

श्रीमान् शाखा प्रमुख ज्यू
क्षमता अभिवृद्धि शाखा
नेपाल स्वास्थ्य अनुसन्धान परिषद
रामशाहपथ, काठमाण्डौं।

विषय: जो जस सँग सम्बन्ध छ।

प्रस्तुत विषयमा, यस गण्डकी प्रदेशमा Portable Digital X-Ray प्रविधिको माध्यमद्वारा एच.आई.भी संक्रमित व्यक्तिहरुमा सक्रिय क्षयरोग खोजपडताल सम्बन्धि अनुसन्धान नभएकोले "Leveraging Portable Digital X-Ray to Strengthen TB Case Finding among People Living with HIV in Gandaki Province of Nepal". सम्बन्धि विषयमा अनुसन्धान गर्न आवश्यक रहेको व्यहोरा अनुरोध छ। गण्डकी प्रदेश अन्तर्गत क्षयरोग नियन्त्रणको उक्त विषयमा अध्ययन/अनुसन्धान गर्न पोखरा महानगरपालिका वडा नं. ४ निवासि पोखरा विश्वविद्यालयका सह प्राध्यापक डा.अमर नागीलाज्यू लाई अनुसन्धान गर्न सिफारिस गरिएको व्यहोरा अनुरोध छ।

.....
डा.सुनिलराज गौतम
नि.निर्देशक

Photo (TB Screening with Digital x-ray)