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DIAGNOSTIC DELAY AS A CRITICAL GAP IN THE TUBERCULOSIS CARE CASCADE: A CROSS-SECTIONAL STUDY FROM BENGALURU, INDIA

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ABSTRACT

Background: Tuberculosis (TB) remains an important public health problem, and timely diagnosis and initiation of treatment are essential to reduce ongoing transmission and improve treatment outcomes. Delays can occur at multiple points in the TB care cascade, including patient-level delay, diagnostic delay and treatment initiation delay. Understanding where the major bottleneck occurs and the factors associated with delay is important for strengthening TB services. Thus the present study aimed to determine the magnitude of diagnostic and treatment delays among tuberculosis patients and to identify factors associated with these delays in the field practice areas of a medical college in Bengaluru, Karnataka.

Materials and Methods: A cross-sectional observational study was conducted over 24 months from March 2024 to February 2026 in the Urban Health Training Centre, Rural Health Training Centre field practice areas and the attached tertiary care hospital of Shri Atal Bihari Vajpayee Medical College and Research Institute, Bengaluru. A total of 160 tuberculosis patients were included. Data regarding sociodemographic characteristics, clinical factors, health-seeking behaviour and healthcare pathways were collected using a predesigned standardized questionnaire. Patient delay was assessed as the interval from onset of illness to first healthcare consultation, diagnostic delay as the interval from first healthcare consultation to TB diagnosis, and treatment delay as the interval from diagnosis to initiation of anti-tubercular treatment. Associations were assessed using appropriate statistical tests, with $p<0.05$ considered statistically significant.

Results: Of the 160 participants, 23 (14.4%) experienced patient delay of >7 days, whereas 54 (33.8%) experienced diagnostic delay of >7 days. Treatment delay of >7 days was observed in 8 (5.0%) participants. The mean patient delay was 4.9 ± 3.6 days, while the mean diagnostic delay was 8.1 ± 6.2 days. Diagnostic delay was significantly associated with education, residence, marital status, TB contact history, first health-seeking action, distance to the first healthcare facility, number of healthcare providers consulted, type of facility where diagnosis was made, sputum-result turnaround time and distance to the nearest designated microscopy centre. Patients with patient delay >7 days were significantly more likely to experience diagnostic delay (65.2% versus 28.5%; $p<0.001$). Diagnostic delay was also significantly associated with subsequent treatment delay (11.1% versus 1.9%; $p=0.012$).

Conclusion: Diagnostic delay represented the major bottleneck in the TB care cascade in this study, despite relatively prompt initial healthcare seeking and treatment initiation after diagnosis. Strengthening early diagnostic pathways,

reducing repeated healthcare visits, improving turnaround time for diagnostic results and ensuring accessible diagnostic services may help reduce delays in TB care.
Keywords: Tuberculosis; diagnostic delay; treatment delay; health-seeking behaviour; TB care cascade; India; community medicine.

INTRODUCTION

Tuberculosis (TB) remains a major global public health challenge despite the availability of effective methods for its diagnosis and treatment. The World Health Organization (WHO) emphasizes timely access to diagnosis and appropriate treatment as essential components of reducing TB-related morbidity, mortality, and transmission. The Global Tuberculosis Report 2025 provides the most recent comprehensive assessment of the global TB epidemic and evaluates progress in TB prevention, diagnosis, and treatment at global, regional, and national levels.[1]

Continued transmission of TB is partly attributable to people with the disease who remain undiagnosed or untreated within the community.1 Consequently, the period between symptom onset and initiation of effective anti-tubercular treatment represents an important component of the TB care cascade. Delays may arise at different stages of this pathway: patients may defer seeking healthcare after developing symptoms, diagnosis may be delayed after initial contact with a healthcare provider, and initiation of treatment may be postponed even after the diagnosis has been established.[2]

Patient delay is generally defined as the interval between the onset of symptoms and the first consultation with a healthcare provider, whereas diagnostic delay refers to the interval between the first healthcare consultation and confirmation of TB. Treatment delay represents the period between diagnosis and initiation of anti-tubercular treatment. A systematic review of studies conducted in India demonstrated considerable variation in the duration of these delays and reported that the number and type of healthcare providers consulted were among the most important determinants of delayed diagnosis and treatment.[2]

Evidence from India indicates that health-system or diagnostic delay may account for a substantial proportion of the overall delay experienced by patients with TB.2,3 A cross-sectional study conducted in Ballabgarh reported that health-system delay was 2.2 times longer than patient delay and was predominantly attributable to delay in establishing the diagnosis. Patients who initially sought care from private health facilities experienced 2.4 times longer health-system delay and 1.7 times longer total delay than those who first approached public health facilities.[3]

More recent evidence from South India further highlights the importance of the diagnostic pathway in determining timely TB care. A 2026 cross-sectional study conducted in Mysuru reported that nearly two-thirds of patients experienced diagnostic delay. Poor TB-related knowledge was strongly associated with patient delay, while socioeconomic vulnerability, initial consultation at a private healthcare facility, and visits to more than three healthcare facilities before diagnosis were important determinants of health-system delay.[4]

In this context, identifying the stage of the care pathway at which delays are concentrated is particularly important for developing appropriate interventions. The present study was therefore undertaken to assess diagnostic and treatment delays among patients with TB and to determine the patient-related, behavioural, clinical, and health-system factors associated with these delays in the field practice areas of a medical college in Bengaluru.

MATERIALS AND METHODS

This cross-sectional observational study was conducted over a period of 24 months, from March 2024 to February 2026, in the Department of Community Medicine, Shri Atal Bihari Vajpayee Medical College and Research Institute (SABVMCRI), Bengaluru. The study was undertaken in the field practice areas of the Urban Health Training Centre and Rural Health Training Centre, as well as at the tertiary care hospital attached to the institution, after obtaining approval from the Institutional Ethics Committee (SABVMCRI/IEC/PG-RP-15/2024). The study included patients diagnosed with pulmonary or extrapulmonary tuberculosis who attended the study centres during the study period. A total of 160 eligible participants were included in the final analysis.

Patients diagnosed with tuberculosis who fulfilled the study eligibility criteria and provided written informed consent were included in the study. Patients who had already completed anti-tubercular treatment, were seriously ill, or did not provide consent were excluded.

Data were collected using a predesigned and standardized questionnaire. Information was obtained regarding socio-demographic characteristics, behavioural factors, clinical characteristics, comorbidities, type of tuberculosis, TB-related knowledge, contact history, health-seeking behaviour, healthcare pathways, and health-system-related factors. Information pertaining to the onset of symptoms, first healthcare consultation, confirmation of tuberculosis diagnosis, and initiation of anti-tubercular treatment was documented to determine delays at different stages of the TB care pathway. Patient delay was defined as the interval between onset of illness or symptoms and the first

healthcare consultation; diagnostic delay as the interval between the first healthcare consultation and confirmation of tuberculosis; and treatment delay as the interval between confirmation of diagnosis and initiation of anti-tubercular treatment. For the present analysis, an interval exceeding 7 days was categorized as delayed for each of the patient, diagnostic, and treatment delay measures.

The collected data were systematically entered into Microsoft Excel and analysed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Prior to analysis, the dataset was reviewed for completeness, consistency, and potential data-entry errors. Categorical variables were summarized as frequencies and percentages. Associations of socio-demographic characteristics, behavioural and clinical factors, health-seeking behaviour, and health-system-related factors with patient, diagnostic, and treatment delays were assessed using the Chi-square test. Fisher's exact test or Yates' continuity correction was applied, as appropriate, when the assumptions of the Chi-square test were not satisfied. Graphical representations, including bar charts and pie diagrams, were generated using Microsoft Excel and Microsoft Word to illustrate relevant distributions and patterns. A two-sided p-value of <0.05 was considered statistically significant after satisfying the assumptions of the respective statistical tests.

RESULTS

Among the 160 participants, most were aged 21–40 years (46.9%), with equal representation of males and females (50% each). The majority were Hindu (59.4%), lived in households with ≤4 members (60.6%), had high school education (41.9%), and belonged to the lower-middle socioeconomic class (49.4%). Unemployment was common (36.9%), while most participants resided in urban areas (73.1%) and were married (63.1%), indicating a predominantly young, urban, married study population. [Table 1]

Table 1: Socio-demographic characteristics of study participants

Socio-demographic characteristics		Frequency (N)	Percentage (%)
Age group	≤20 years	26	16.3%
	21 to 40 years	75	46.9%
	41 to 60 years	46	28.8%
	>60 years	13	8.1%
Gender	Female	80	50.0%
	Male	80	50.0%
Religion	Hindu	95	59.4%
	Christian	17	10.6%
	Muslim	48	30.0%
Number of Household Members	≤4 members	97	60.6%
	>4 members	63	39.4%
Education	Illiterate	17	10.6%
	Primary School	25	15.6%
	High School	67	41.9%
	Diploma / PU	33	20.6%
	Degree	18	11.3%
Occupation	Student	33	20.6%
	Unemployed	59	36.9%
	Unskilled	25	15.6%
	Semi-Skilled	19	11.9%
	Skilled	14	8.8%
	Semi Professional	7	4.4%
	Professional	3	1.9%
Socioeconomic Status (Modified BG Prasad Classification)	Upper Class	5	3.1%
	Upper Middle	13	8.1%
	Middle Class	54	33.8%
	Lower Middle	79	49.4%
	Lower Class	9	5.6%
Residence	Urban	117	73.1%
	Rural	43	26.9%
Marital Status	Married	101	63.1%
	Single	42	26.3%
	Separated	3	1.9%

Most participants experienced limited delay across the TB care pathway. Patient delay averaged 4.9 ± 3.6 days, with 23 (14.4%) experiencing >7 days delay. Diagnostic delay was the most frequent, averaging 8.1 ± 6.2 days and affecting 54 (33.8%) participants. Confirmation delay was minimal (2.3 ± 1.9 days), with 96.9% confirmed within 7 days. Treatment initiation was prompt (3.2 ± 2.7 days), with only 8 (5.0%) experiencing treatment delay. [Table 2, Figure 1]

Table 2: Delays in TB care pathway

Delays in TB care pathway	Mean	SD	Median	IQR
Patient Delay (Duration of illness before first consultation)	4.9	3.6	4	3 - 6
Diagnosis Delay (Days from first healthcare seeking to TB diagnosis)	8.1	6.2	6	4 - 10

Confirmation Delay (Days from sputum examination to TB+ result)	2.3	1.9	2	1 - 3
Treatment Delay (Days from diagnosis to starting ATT)	3.2	2.7	2	1 - 4

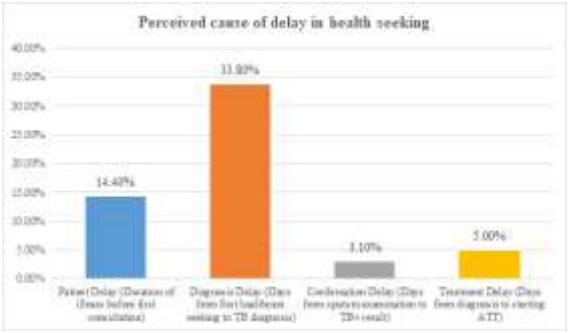

Figure 1: Perceived cause of delay in health seeking

Diagnostic delay was significantly associated with education, residence, and marital status. It was highest among illiterate participants (58.8%) and those with primary education (48.0%), but lower among degree holders (16.7%; p=0.011). Rural participants had greater delay than urban residents (48.8% vs 28.2%; p=0.024). Delay was also highest among widowed participants (57.1%) and lowest among singles (14.3%; p=0.009). Other socio-demographic factors showed no significant association. [Table 3]

Table 3: Association between socio-demographic factors and diagnostic delay

Socio-demographic factors vs. Diagnostic delay		Days from first healthcare seeking to TB diagnosis				p-value
		≤7 days		>7 days		
		N	%	N	%	
Age group	≤20 years	20	76.9	6	23.1	0.185
	21 to 40 years	53	70.7	22	29.3	
	41 to 60 years	26	56.5	20	43.5	
	>60 years	7	53.8	6	46.2	
Gender	Female	56	70.0	24	30.0	0.403
	Male	50	62.5	30	37.5	
Religion	Hindu	64	67.4	31	32.6	0.780
	Christian	12	70.6	5	29.4	
	Muslim	30	62.5	18	37.5	
Number of Household Members	≤4 members	68	70.1	29	29.9	0.268
	>4 members	38	60.3	25	39.7	
Education	Illiterate	7	41.2	10	58.8	0.011*
	Primary School	13	52.0	12	48.0	
	High School	44	65.7	23	34.3	
	Diploma / PU	27	81.8	6	18.2	
	Degree	15	83.3	3	16.7	
Occupation	Student	27	81.8	6	18.2	0.122
	Unemployed	34	57.6	25	42.4	
	Unskilled	13	52.0	12	48.0	
	Semi-Skilled	14	73.7	5	26.3	
	Skilled	10	71.4	4	28.6	
	Semi Professional	5	71.4	2	28.6	
	Professional	3	100.0	0	0.0	
Socioeconomic Status	Upper Class	5	100.0	0	0.0	0.115
	Upper Middle	10	76.9	3	23.1	
	Middle Class	40	74.1	14	25.9	
	Lower Middle	46	58.2	33	41.8	
	Lower Class	5	55.6	4	44.4	
Residence	Urban	84	71.8	33	28.2	0.024*
	Rural	22	51.2	21	48.8	
Marital Status	Married	62	61.4	39	38.6	0.009*
	Single	36	85.7	6	14.3	
	Separated	2	66.7	1	33.3	
	Widowed	6	42.9	8	57.1	

* Statistically significant

Diagnostic delay was higher among smokers (46.4%) and alcohol users (50.0%) than their counterparts, although these associations were not statistically significant (p=0.180 and p=0.075, respectively). Absence of TB contact history was significantly associated with greater diagnostic delay (48.6% vs 29.3%; p=0.047). Co-morbidity showed no significant association (p=0.473), although delay was relatively higher among participants with diabetes mellitus (46.2%). [Table 4]

Table 4: Association between behavioural and clinical risk factors and diagnostic delay

Behavioural and clinical risk factors vs. Diagnostic delay		Days from first healthcare seeking to TB diagnosis				p-value
		≤7 days		>7 days		
		N	%	N	%	
H/o Current Smoking	Yes	15	53.6	13	46.4	0.180
	No	91	68.9	41	31.1	

H/o Alcohol Consumption	Yes	14	50.0	14	50.0	0.075
	No	92	69.7	40	30.3	
H/o Contact with TB Patients	Yes	87	70.7	36	29.3	0.047*
	No	19	51.4	18	48.6	
Presence of Co-morbidities	None	78	72.2	30	27.8	0.473
	DM	7	53.8	6	46.2	
	HTN	1	50.0	1	50.0	
	DM + HTN	4	50.0	4	50.0	
	HIV / AIDS	4	50.0	4	50.0	
	COPD	1	50.0	1	50.0	
	Others	11	57.9	8	42.1	

* Statistically significant

Diagnostic delay was significantly associated with health-seeking behaviour. Delay was higher among those using self-medication (71.4%), traditional medicine (100%), or drug stores (80.0%; p=0.007). Participants residing >10 km from the first healthcare facility also had greater delay than those living within 10 km (58.8% vs 30.8%; p=0.029). Type of first facility and reason for consultation were not significantly associated with diagnostic delay. [Table 5]

Table 5: Association between health-seeking behaviour and diagnostic delay

Health-seeking behaviour vs. Diagnostic delay		**Days from first healthcare seeking to TB diagnosis**				**p-value**
		≤7 days		**>7 days**		
		N	**%**	**N**	**%**	
First action taken after onset of symptoms	Health Care Provider	103	70.1	44	29.9	0.007*
	Self-Medication	2	28.6	5	71.4	
	Traditional Medicine	0	0.0	1	100.0	
	Over The Counter Drugs	1	20.0	4	80.0	
First health facility consulted	Government	72	72.0	28	28.0	0.070
	Private	34	56.7	26	43.3	
Distance from home to first facility	≤10 km	99	69.2	44	30.8	0.029*
	>10 km	7	41.2	10	58.8	
Reason for first consultation at that facility	Accessible	39	78.0	11	22.0	0.075
	Confidence in getting cured	27	57.4	20	42.6	
	Services available anytime	6	50.0	6	50.0	
	Referred by previous HCP	8	50.0	8	50.0	
	Free services	11	84.6	2	15.4	
	Advised by somebody	15	68.2	7	31.8	

* Statistically significant

Diagnostic delay was strongly associated with health-system factors. Delay was markedly higher among participants consulting >3 healthcare providers (75.0%; p<0.001) and among those diagnosed in private facilities (44.2% vs 21.6%; p=0.003). All participants with sputum result delays >7 days experienced diagnostic delay (100%; p=0.002). Greater distance to the nearest DMC was also significant, with higher delay among those residing >10 km away (62.5% vs 28.7%; p=0.001). [Table 6]

Table 6: Association between health system factors and diagnostic delay

Health system factors vs. Diagnostic delay		**Days from first healthcare seeking to TB diagnosis**				**p-value**
		≤7 days		**>7 days**		
		N	**%**	**N**	**%**	
No. of HCPs consulted before diagnosis	≤3 HCP	99	75.0	33	25.0	<0.001*
	>3 HCP	7	25.0	21	75.0	
Health facility where initial TB diagnosis was made	Government	58	78.4	16	21.6	0.003*
	Private	48	55.8	38	44.2	
Days from sputum submission to TB positive result	≤7 days	106	68.4	49	31.6	0.002*
	>7 days	0	0.0	5	100.0	
Distance from home to nearest DMC	≤10 km	97	71.3	39	28.7	0.001*
	>10 km	9	37.5	15	62.5	

* Statistically significant

Diagnostic delay was significantly associated with education, residence, marital status, and absence of previous TB contact (p<0.05). Delay was also higher among participants initially using self-medication, traditional medicine, or over-the-counter drugs (p=0.007) and those residing >10 km from the first facility (p=0.029). Health-system factors were particularly important, with >3 healthcare-provider consultations, private-facility diagnosis, delayed sputum results, and greater distance to the nearest DMC significantly associated with diagnostic delay (p<0.05).

Patient delay was significantly associated with subsequent diagnostic delay. Among participants seeking care within 7 days, 28.5% experienced diagnostic delay, compared with 65.2% of those who

sought care after >7 days (p<0.001). This indicates that delays occurring early in the TB care pathway may contribute to further delays in establishing the diagnosis. [Table 7]

Table 7: Association between patient delay and diagnostic delay

Patient delay vs. Diagnostic delay		Days from first healthcare seeking to TB diagnosis				p-value
		≤7 days		>7 days		
		N	%	N	%	
Duration of illness before first consultation	≤7 days	98	71.5	39	28.5	<0.001*
	>7 days	8	34.8	15	65.2	

* Statistically significant

DISCUSSION

The principal finding of the present study was that diagnostic delay represented the major bottleneck in the TB care cascade. While only 14.4% of participants experienced patient delay and 5.0% experienced treatment delay, approximately one-third had diagnostic delay. This pattern highlights the importance of delays occurring after patients have entered the healthcare system. An Indian systematic review reported median patient and diagnostic delays of 18.4 and 31 days, respectively, demonstrating the substantial contribution of diagnostic pathways to overall TB-related delay.[2]

The relatively low patient delay observed in the present study may reflect greater awareness, accessibility of healthcare facilities, and availability of TB services in the study setting. Nevertheless, considerable delay occurred between patients entering the healthcare system and confirmation of TB, indicating that timely care-seeking alone may not ensure prompt diagnosis. Similar Indian evidence has demonstrated that health-system delays can remain substantial even after patients seek healthcare.[2,5]

The association between the number of healthcare providers consulted and diagnostic delay was particularly important. Three-fourths of participants who consulted more than three healthcare providers experienced diagnostic delay. This finding is consistent with previous Indian studies identifying multiple provider consultations as an important contributor to prolonged diagnostic pathways.2,5,6 The Southern Indian study by Balasubramnian et al. specifically identified consultation with two or more doctors as an independent predictor of health-system delay.[6]

The present study also demonstrated an association between private-sector diagnosis and diagnostic delay. Although the type of initial facility was not significantly associated with delay, the facility where TB was ultimately diagnosed showed a significant association. Previous Indian studies have similarly demonstrated delays associated with private-sector healthcare pathways.[2,6,7] In Ballabgarh, 76% of patients initially sought care from private facilities, and those initially visiting private facilities experienced longer health-system and total delays than those approaching public facilities.[5]

The finding that delayed sputum results were associated with diagnostic delay has direct programmatic relevance. All participants who received sputum results after more than seven days experienced diagnostic delay. This finding emphasizes the need for timely specimen transportation, laboratory processing, testing, and communication of results to facilitate prompt diagnosis and linkage to treatment.

Geographical accessibility also emerged as an important determinant. Participants residing more than 10 km from the first healthcare facility or the nearest Designated Microscopy Centre (DMC) experienced substantially greater diagnostic delay. This indicates that physical accessibility to diagnostic services may remain an important barrier even within urban and peri-urban healthcare settings.

Another important finding was the association between patient delay and subsequent diagnostic delay. Participants with patient delay >7 days experienced diagnostic delay more frequently than those who sought care earlier (65.2% versus 28.5%; p<0.001). This suggests that delays at different stages of the TB care cascade may be interconnected rather than operating independently. Complex pathways involving repeated consultations and delayed referral have similarly been identified as contributors to prolonged TB care pathways in Indian studies.[2,7]

Diagnostic delay was also associated with subsequent treatment delay. Although treatment delay was relatively uncommon in the present study, its greater occurrence among participants experiencing diagnostic delay suggests that prolonged diagnostic pathways may have downstream effects on treatment initiation. Previous Indian evidence has identified patient-, provider-, and health-system-related factors contributing to delays between TB diagnosis and treatment initiation.[6,8]

Recent evidence from Karnataka further supports these findings. A 2026 cross-sectional study from Mysuru reported that nearly two-thirds of patients experienced diagnostic delay and identified socioeconomic vulnerability, initial consultation at private healthcare facilities, and visits to more than three healthcare facilities before diagnosis as important determinants of health-system delay.4 The geographical proximity and similarity of these findings strengthen their relevance to TB control strategies in Karnataka.

Public Health Implications: The findings indicate that interventions aimed at reducing delays in tuberculosis care should extend beyond promoting early healthcare-seeking behaviour. As diagnostic delay emerged as the predominant bottleneck, a

coordinated approach addressing community-, healthcare-provider-, and health-system-level barriers may be more appropriate.

- Community-Level Interventions: At the community level, efforts should focus on improving early recognition of symptoms suggestive of tuberculosis and encouraging timely consultation with qualified healthcare providers. TB-related stigma, misconceptions, and misinformation should be addressed through targeted health education. Self-medication and prolonged use of over-the-counter medications should also be discouraged, as these practices may delay appropriate evaluation and diagnosis.
- Healthcare-Provider-Level Interventions: At the healthcare-provider level, screening for tuberculosis among presumptive cases should be strengthened, particularly among patients with persistent respiratory or constitutional symptoms. Referral mechanisms should be streamlined to minimize repeated consultations before diagnosis. Greater engagement of private healthcare providers with the national TB programme may also facilitate earlier diagnosis, standardized referral, and timely notification.
- Health-System-Level Interventions: At the health-system level, accessibility and availability of diagnostic services should be improved, particularly for populations residing farther from diagnostic centres. Delays related to specimen transportation, laboratory processing, reporting, and communication of results should be minimized. Wider and timely use of rapid diagnostic tests, stronger linkage between diagnosis and treatment initiation, and closer coordination between public and private healthcare services may further reduce delays along the TB care cascade. These measures are particularly relevant because recent Indian evidence continues to demonstrate an important contribution of health-system pathways to diagnostic and treatment delays.

Strengths and limitations: The study comprehensively assessed patient, diagnostic, and treatment delays and their socio-demographic, behavioural, clinical, health-seeking, and health-system determinants across urban, rural, and tertiary-care settings using a standardized questionnaire. However, its cross-sectional design precluded causal inference, while recall and social-desirability bias may have influenced reported information. Single-institution recruitment may limit generalizability, and relatively small subgroup sizes may have reduced statistical power for certain comparisons.

CONCLUSION

Diagnostic delay was the principal gap in the TB care cascade, affecting nearly one-third of participants despite generally prompt care seeking and treatment initiation. It was significantly associated with sociodemographic factors, health-seeking behaviour, geographical accessibility, repeated healthcare consultations, diagnostic facility type, and test-result turnaround time. Patient delay was associated with subsequent diagnostic delay, which in turn influenced treatment delay. TB control efforts should therefore prioritize rapid diagnosis, accessible diagnostic services, efficient referral pathways, and stronger public-private healthcare integration alongside promotion of early care seeking.

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