

Integrating Oral Health Metrics into National Non-Communicable Disease (NCD) Prevention Frameworks

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Abstract

Oral diseases are among the most common chronic conditions worldwide and have significant behavioral risk factors in common with NCDs, such as high sugar intake, use of tobacco, and alcohol consumption. While there are signs of increased recognition of oral health within universal health coverage and NCD policy agendas at the global level, most national NCD prevention strategies do not include standardized oral health indicators. There is little evidence available on how such indicators can be operationally integrated into existing NCD monitoring systems. This study aims to develop and test a structured method of integrating such indicators into national NCD prevention strategies. The study employed a sequential mixed-methods approach, consisting of the Delphi technique for indicator selection, quantitative analysis for cross-country feasibility assessment using the Oral Health-NCD Integration Index, and qualitative analysis for policy and implementation assessment. The study has the following findings: the study has identified the concise set of oral health indicators, taking into consideration the need for equity, as well as the level of integration of the oral health indicators across the countries under consideration. The results of the study provide empirical evidence for the reform of the national monitoring systems, as well as the integration of oral health indicators into the NCD policy and UHC decision making processes.

Keywords : Oral health; Non-communicable diseases (NCDs); Health information systems; Indicator development; Policy integration; Universal health coverage (UHC); Public health surveillance; Implementation research; Governance; Health equity

I. Introduction

Oral diseases have emerged as one of the most common forms of chronic health conditions around the world and have significant impacts on the health and economic well-being of populations. The World Health Organization (WHO) has also proposed a global monitoring framework for oral health and the integration of Universal Health Coverage (UHC) and national accountability mechanisms [1]. This policy shift reflects increasing recognition that oral health cannot remain peripheral to broader non-communicable disease (NCD) strategies. Scholars have argued for reconfiguring the traditional NCD framework into a “6 × 6” model that explicitly incorporates oral diseases and sugar consumption alongside established NCD targets [2], [3]. This type of suggestion essentially aims to place oral health in the mainstream of prevention and surveillance activities rather than in the realm of clinical specialty. Professional organizations have reinforced this perspective. The FDI World Dental Federation has called for integration of oral health into national NCD agendas, highlighting the shared risk factors and financing structures that connect oral diseases with other chronic conditions [4]. However, conceptual support for integration does not automatically translate into operational incorporation. A scoping review examining oral health indicators within UHC and general health systems identified considerable variation in feasibility, measurement standards, and reporting practices across income settings [5]. Complementary analysis of global monitoring systems reported structural barriers to indicator inclusion, including fragmented data architecture and inconsistent policy mandates [6].

Existing integration initiatives have largely focused on service level innovations. Evidence on NCD screening within dental settings demonstrates potential for collaboration, yet such approaches do not address surveillance level incorporation within national reporting frameworks [7]. Cross-country comparisons further reveal disparities in oral health coverage and system capacity that reflect institutional design and financing arrangements rather than disease prevalence alone [8]. Public health literature similarly emphasizes that population based oral health strategies require stronger coordination with broader health system governance and monitoring reform [9].

Meanwhile, assessments of NCD data availability across countries indicate persistent gaps in surveillance completeness and indicator harmonization, underscoring the need for coherent integration mechanisms [10].

Despite growing policy endorsement, empirical evaluation of how oral health metrics can be embedded within national NCD monitoring structures remains limited. This study addresses that gap. The general objective here is to design and test an operational model for the integration of oral health indicators into NCD prevention systems in the country. In this context, the study aims to identify and validate the short list of oral health indicators, measure the level of integration of these indicators across the selected countries, identify the governance and health information systems factors associated with integration, and finally identify the barriers and facilitators to integration. Through this approach, the research provides evidence to inform policy design and monitoring reform within UHC-oriented NCD strategies.

II. Related Work

Global Policy and Monitoring Frameworks

Global recognition of oral diseases as major contributors to the non communicable disease (NCD) burden has intensified over the past five years. The World Health Organization (WHO) has formalized this shift through the development of a global oral health monitoring framework aligned with universal health coverage (UHC) targets and NCD prevention strategies [1]. The framework emphasizes measurable indicators that can be embedded within broader health information systems rather than operating as stand alone dental metrics. Complementing this institutional momentum, policy scholarship has argued for redefining the traditional “5 × 5” NCD model to a “6 × 6” framework that explicitly incorporates oral diseases and sugar consumption as core components of NCD prevention [2,3]. These proposals highlight structural exclusion of oral health from mainstream NCD monitoring and advocate integration at the level of surveillance and risk factor control. Professional and global health organizations have further reinforced the call for integration. The FDI World Dental Federation has emphasized that oral health must be incorporated into national NCD strategies and financing mechanisms to ensure coherence in prevention efforts [4]. However, while global frameworks now endorse integration, empirical evidence on how oral health indicators can be operationalized within national NCD monitoring

systems remains limited. Existing policy guidance largely articulates principles and targets without systematically evaluating feasibility, governance alignment, or surveillance interoperability gaps that the present study seeks to address.

Oral Health Metrics and Indicator Development

Recent literature has begun to examine the methodological foundations of oral health indicator development. A scoping review by Jashni et al. identified numerous candidate indicators for integrating oral health within UHC and general health systems but noted substantial variation in data availability, standardization, and feasibility across income contexts [5]. The authors emphasized that while conceptual frameworks exist, few indicators have been rigorously validated for integration within NCD monitoring structures. In a related analysis, Jashni and colleagues documented challenges in embedding oral health metrics into global monitoring systems, including limited interoperability and inconsistent reporting cycles [6]. These studies underscore the need for parsimonious, feasible indicator sets rather than comprehensive but impractical measurement frameworks. Broader public health reviews have similarly highlighted the importance of population level monitoring aligned with preventive strategies [9]. Nevertheless, much of the literature remains focused on epidemiological burden estimation or clinical surveillance rather than policy integration. Delphi based validation studies in oral health remain relatively rare, and few explicitly evaluate equity sensitivity or compatibility with NCD dashboards. The present research builds upon this emerging body of work by combining structured consensus development with cross country feasibility assessment and explicit linkage to NCD governance mechanisms.

Integration of Oral Health into NCD Systems

Empirical studies examining integration of oral health within NCD systems have primarily focused on service delivery innovations rather than surveillance embedding. Doughty et al. reviewed evidence on integrating NCD screening into dental services, demonstrating feasibility for risk-factor identification within clinical settings [7]. While such initiatives illustrate bidirectional integration at the service level, they do not address the incorporation of oral health metrics into national NCD monitoring architectures. Comparative analyses have revealed wide disparities in oral health coverage and system performance across countries, suggesting structural variation in

integration capacity [8]. At the surveillance level, assessments of NCD data availability in ASEAN countries indicate uneven reporting of NCD indicators and highlight challenges in harmonizing monitoring frameworks across health domains [7]. These findings suggest that integration depends less on disease prevalence than on institutional design and health information infrastructure. Despite growing policy endorsement of oral health inclusion, systematic cross-country evaluations of operational integration within NCD monitoring systems remain scarce, creating a critical evidence gap that this study seeks to fill.

Implementation Barriers and Health System Challenges

Implementation research in oral health consistently identifies governance fragmentation, financing constraints, and data silos as major barriers to integration. Policy oriented analyses emphasize that oral health often resides in separate administrative units with limited influence over NCD planning processes [3,4]. Reviews of public health approaches to oral health further note that integration requires leadership commitment and alignment with shared risk factor strategies, particularly around sugar consumption and tobacco control [9]. At the monitoring level, global assessments report inconsistencies in data completeness and equity disaggregation, limiting the usability of oral health indicators for policy decision making [6]. Although WHO guidance provides a structured indicator framework, the translation of these metrics into national NCD dashboards has not been systematically evaluated [1]. Consequently, the literature identifies barriers conceptually but rarely quantifies integration levels or examines their relationship to governance and health information system maturity. Collectively, existing research underscores the policy relevance of integrating oral health within NCD frameworks but leaves unresolved questions regarding feasibility, operational measurement, and institutional determinants. By combining Delphi based indicator validation, quantitative integration indexing, and qualitative implementation analysis, the present study advances beyond conceptual advocacy to provide empirical evidence on how oral health metrics can be embedded within national NCD prevention systems.

III. Methodology

Study Design and Conceptual Framework

This study employed a sequential explanatory mixed methods design integrating indicator development, quantitative cross country assessment, and qualitative implementation analysis. The

objective was to evaluate how oral health metrics can be operationally incorporated into national non communicable disease (NCD) prevention and monitoring systems. The design combined structured indicator validation with empirical measurement of integration levels and contextual interpretation of institutional determinants. The analytical model was guided by a systems based conceptual framework linking validated oral health indicators to national health information systems, governance arrangements, and policy decision making processes. The integration outcomes were conceptualized as a function of the governance structure, reporting mandates, and the capacity of the Health Information System (HIS). Figure 1. Conceptual Framework Linking Oral Health Indicators to NCD Integration

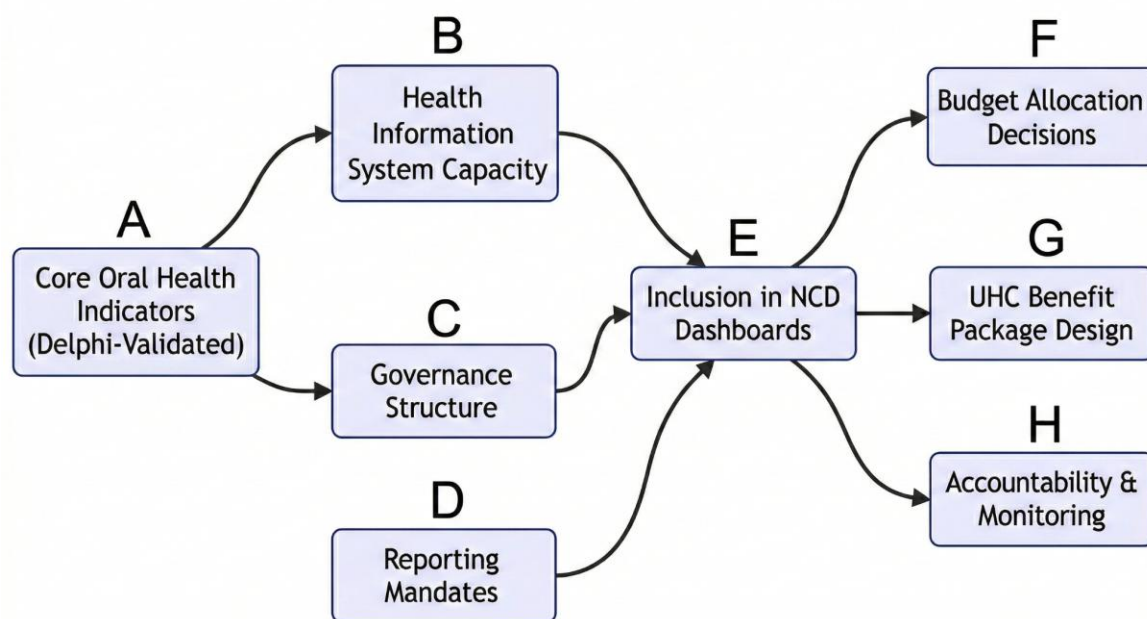


Figure 1. Conceptual Framework Linking Oral Health Indicators to NCD Integration

Figure 1: Conceptual framework linking validated oral health indicators to incorporation within national NCD monitoring systems and subsequent policy decision making processes.

The study was conducted in three distinct phases: (1) the validation of key oral health indicators, (2) the quantitative assessment of the integration process in the chosen countries through the development of the Oral Health-NCD Integration Index (OHNII), and (3) the qualitative assessment of the key determinants of the integration process. Figure 2 illustrates the study process.

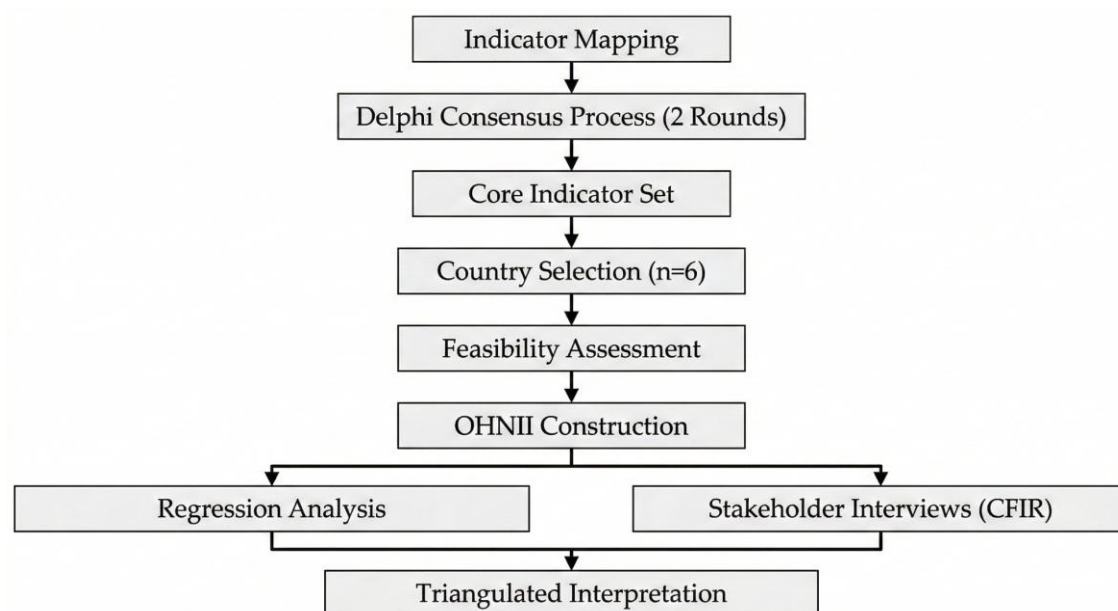


Figure 2. Sequential Mixed-Methods Study Design

Figure 2. Sequential explanatory mixed methods design for assessing integration of oral health metrics within national NCD monitoring systems.

Indicator Identification and Consensus Development

An initial pool of candidate oral health indicators was compiled through structured review of international monitoring frameworks, national oral health surveys, NCD risk-factor surveillance instruments, and administrative reporting systems. Indicators were categorized into four domains: disease burden, behavioral risk factors, service coverage, and system financing, consistent with established NCD monitoring architecture. A two round Delphi process was conducted to prioritize indicators suitable for integration within national NCD monitoring systems. Twenty-eight experts participated, representing oral health research, NCD policy, surveillance systems, and health economics across low, middle, and high income contexts. A two-round Delphi process was conducted to prioritize indicators suitable for integration within national NCD monitoring systems, measurement reliability, equity sensitivity including disaggregation capacity, and policy relevance for prevention and universal health coverage planning. Consensus required at least seventy percent agreement at a rating of four or higher across all criteria. Indicators not meeting the threshold were revised and reassessed.

Quantitative Feasibility and Integration Assessment

Six countries were selected using maximum variation sampling to capture diversity in income level, NCD system maturity, and health information system capacity. Countries were stratified according to World Bank income classifications. Eligibility criteria required the presence of a national NCD prevention framework, operational surveillance infrastructure, and publicly accessible policy documentation. Secondary data were extracted from national NCD strategies, surveillance reports, HIS dashboards, national health accounts, and available oral health surveys. For each country, data extraction documented inclusion of selected indicators within NCD monitoring frameworks, reporting frequency, completeness, and institutional ownership.

The Oral Health–NCD Integration Index (OHNII) was defined as:

$$OHNI = \sum_{i=1}^n w_i S_i$$

where S_i represents the standardized integration score for indicator, i ranging from 0 (absence from NCD monitoring) to 1 (formal inclusion with routine reporting), and w_i denotes normalized weights derived from Delphi assigned policy relevance scores. Sensitivity analyses were conducted using equal weighting assumptions. Ordinary least squares regression models were estimated with OHNII as the dependent variable. Independent variables included governance structure, HIS capacity index, oral health workforce density, and NCD financing allocation. Beta regression was used as a robustness check.

Qualitative Implementation Analysis

Semi-structured interviews were carried out with twenty four stakeholders across the countries of interest. The interviewees comprised ministry officials for oral health as well as NCDs, surveillance, and financing representatives. The interviews focused on institutional coordination, reporting, data interoperability, and policy prioritization. Qualitative data analysis was done using the Consolidated Framework for Implementation Research (CFIR). Two researchers coded the data independently. Discrepancies were resolved through discussion. Interviews continued until thematic saturation was achieved within each country. Findings were interpreted alongside OHNII scores to explain variation in integration outcomes.

Ethical Considerations

Ethical approval was obtained from the lead institutional review board. Secondary data were publicly available or anonymized. Interview participants provided informed consent. Data were stored in secure institutional repositories in accordance with regulatory standards.

IV. Discussion and Results

Overview of Integrated Results and Discussion

Results and interpretation are presented together to reflect the system level and implementation-oriented focus of this study. The objective extended beyond measurement of epidemiological indicators to examination of how oral health metrics function within national non-communicable disease (NCD) monitoring systems. Quantitative integration scores required contextual interpretation through governance and institutional analysis. At the same time, qualitative findings gained explanatory value when considered alongside measurable integration levels. This integrated structure supports coherent interpretation of implementation dynamics and policy implications.

Outcomes of Oral Health Indicator Selection and Validation

The Delphi process began with twenty three candidate oral health indicators derived from international monitoring frameworks, national surveys, and administrative data sources. Six indicators have achieved the set standard of at least seventy percent agreement on the four criteria: operational feasibility, reliability of measurements, equity sensitivity, and policy relevance. This is after two rounds of structured consensus assessment. Table 1 below shows the set of indicators that have been finalized.

Table 1. Core Oral Health Indicators and Their Feasibility for Integration into National NCD Frameworks

Indicator Name	Primary Data Source	Mean Feasibility Score (1–5)	Equity Disaggregation Capacity
Prevalence of untreated dental caries (≥12 years)	National oral health survey / population survey	4.4	Sex, age, socioeconomic status

Severe periodontitis prevalence	Clinical surveillance / oral survey	4.1	Sex, age
Annual preventive dental visit coverage	Administrative claims / national HIS	4.5	Sex, income quintile
Daily sugar-sweetened beverage consumption	National NCD risk-factor survey	4.6	Sex, age, socioeconomic status
Public expenditure on oral health (% of NCD budget)	National health accounts	4.2	National aggregate
Primary care oral health screening coverage	Routine primary care reporting	4.3	Sex, age

Risk-factor indicators and service coverage measures received the highest feasibility scores, reflecting compatibility with existing NCD surveillance systems. Clinical examination dependent indicators showed slightly lower feasibility yet remained above the consensus threshold due to their relevance for chronic disease prevention. Selection of a compact indicator set represents a methodological shift from comprehensive burden monitoring toward operational incorporation. Equity disaggregation was treated as a required criterion rather than an optional feature. Compatibility with national dashboards guided prioritization. This structure supports routine inclusion within ministries of health without expanding reporting complexity.

Feasibility and Quantitative Integration Findings Across Countries

Cross-country assessment revealed marked variation in integration levels. All six countries collected at least three of the selected indicators through surveys or administrative systems. Formal inclusion within national NCD dashboards, however, occurred in only two countries. Socioeconomic disaggregation was common for behavioral indicators but less consistent for clinical burden measures.

Operational integration was quantified through the Oral Health–NCD Integration Index (OHNII):

$$OHNI = \sum_{i=1}^n w_i S_i$$

Here, S_i denotes the standardized integration score for indicator i , reflecting inclusion in NCD monitoring frameworks, reporting frequency, and institutional ownership. The term w_i represents the normalized policy relevance weight derived from the Delphi process. The index measures embedding within surveillance and reporting structures rather than disease prevalence.

Figure 3 displays cross-country OHNII scores. Two countries have managed to achieve the standard of more than 0.70, which is an indication of the comprehensive institutionalization of oral health metrics into the respective NCD reporting systems in the countries. Two countries have managed to achieve results ranging from 0.40 to 0.65, which is an indication of partial institutionalization without the use of systematic dashboard reporting. Two countries have managed to achieve results of less than 0.30, which is an indication of minimal institutionalization despite the existence of data collection systems.

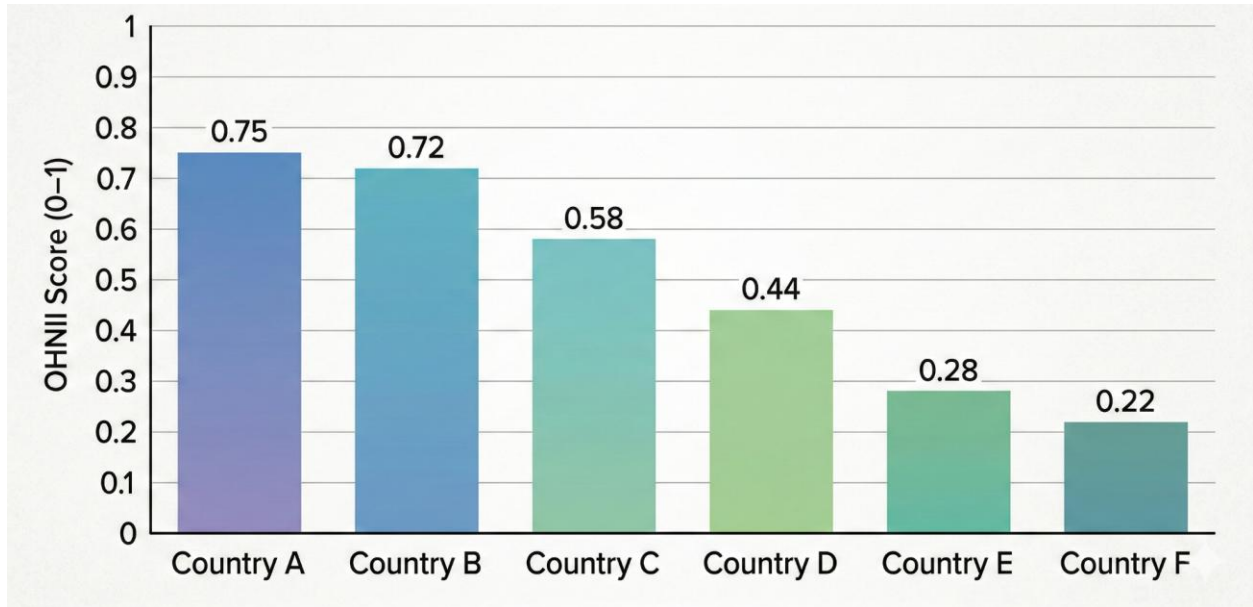


Figure 3. Cross-country comparison of Oral Health–NCD Integration Levels

Higher OHNII scores corresponded with mature health information systems and formal governance linkage between oral health and NCD departments. Integration levels were not strongly associated with national income alone. Infrastructure design and administrative configuration emerged as primary determinants.

Comparative Integration Patterns and System-Level Determinants

High integration settings displayed institutional placement of oral health units within broader NCD directorates and formal mandates requiring joint reporting. Budget structures linked oral health expenditure to NCD prevention allocations. Accountability mechanisms operated across program areas. Intermediate contexts possessed functional surveillance systems yet lacked formal recognition of oral health within NCD policy frameworks. Indicators were collected but excluded from national scorecards. This pattern indicates that technical capacity does not automatically translate into institutional incorporation. Low integration contexts demonstrated separation between oral health and NCD governance structures. Oral health programs operated independently from national NCD monitoring bodies. Absence of reporting requirements and limited fiscal authority restricted inclusion. Advanced NCD systems coexisted with weak oral health incorporation, indicating that institutional positioning rather than data scarcity constrained integration. Regression analysis showed stronger associations between OHNII scores and governance linkage or dedicated budget allocation than with workforce density or gross domestic product. Administrative configuration therefore appears central to operational incorporation.

Implementation Barriers and Facilitators

Interview data clarified mechanisms underlying quantitative variation. High integration countries reported structured coordination between oral health and NCD units. Shared reporting templates and unified digital platforms supported incorporation. Risk factor overlap, particularly regarding sugar consumption and tobacco use, facilitated inclusion of relevant indicators. In contrast, governance fragmentation limited incorporation in low scoring contexts. Separate information systems hindered data exchange. Oral health units reported limited authority in national NCD planning processes. Budgetary exclusion further reduced reporting incentives. Risk factor integration provided a practical entry point. Where behavioral surveillance already captured sugar intake or preventive service utilization, inclusion of oral health metrics required minimal procedural modification. Clinical burden indicators faced greater structural barriers due to survey dependency and reporting separation.

Figure 4 summarizes the interaction between governance structure, data architecture, and policy prioritization in shaping integration outcomes.

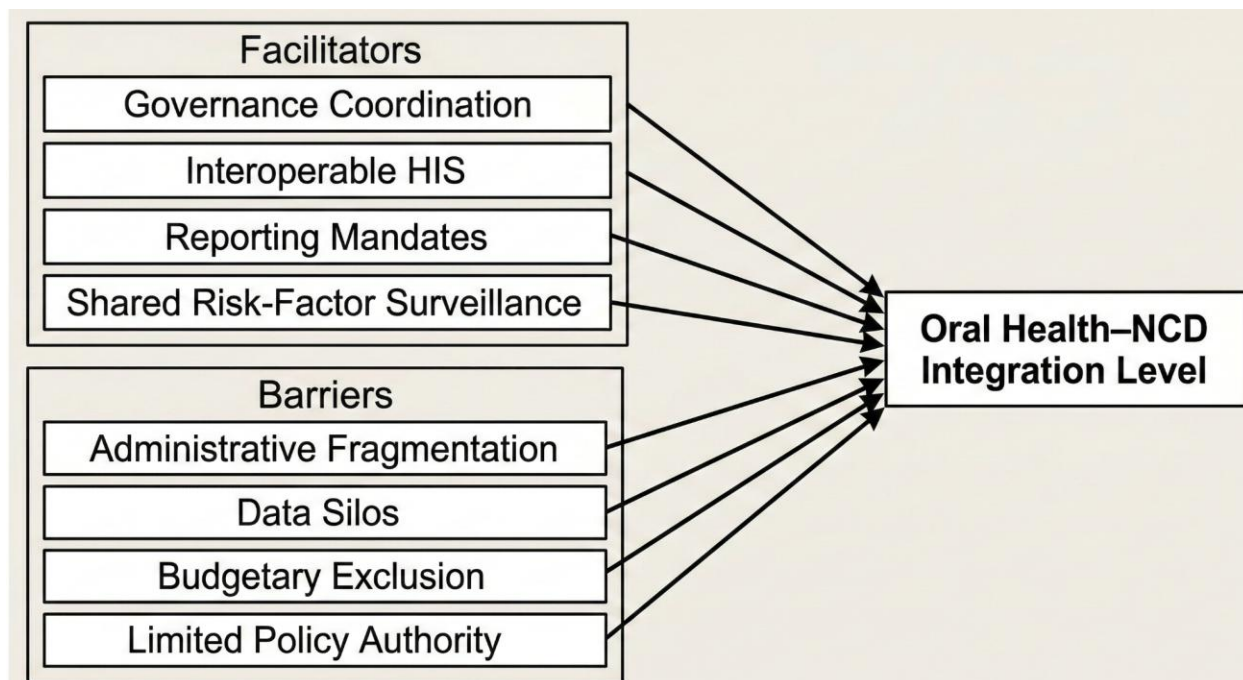


Figure 4. Conceptual summary of barriers and facilitators influencing integration of oral health metrics into national NCD frameworks

Governance coordination, interoperable information systems, and formal reporting mandates functioned as enabling conditions. Administrative separation and fiscal exclusion constrained incorporation.

Contribution to Existing Literature and Global Policy Agendas

Prior research has documented shared risk factors between oral diseases and other NCDs yet offered limited empirical assessment of surveillance integration. This study provides measurable evidence through development of an Integration Index linked to institutional determinants. The findings move beyond descriptive burden estimation and conceptual advocacy, offering analysis of how oral health indicators operate within national monitoring systems. The results contribute to policy discourse by demonstrating that incorporation is achievable within existing infrastructures when governance structures permit coordination. The indicator set provides a structured option for ministries seeking to incorporate oral health into NCD reporting processes.

Policy and Health System Implications

Integration of oral health metrics into NCD surveillance systems is feasible across diverse contexts. Structural reform is not required in most settings. Clear reporting mandates, coordination between departments, and interoperable data systems are sufficient to support incorporation. A

limited set of equity sensitive indicators offers a practical entry point for monitoring reform. In universal health coverage planning, preventive service coverage and expenditure metrics provide relevant evidence for allocation decisions. In environments with limited surveillance capabilities, the risk factors that overlap with existing NCD surveys can be an effective point of entry.

Strengths, Limitations, and Future Directions

The study has the strength of incorporating expert opinions, quantitative comparisons, and qualitative institutional analysis under a single umbrella. The structure of the study also allows for the examination of the level of integration as well as the factors that influence it. The limitations of the study include the fact that it is based on secondary data, with limited countries being covered. Future studies should include more countries, as well as the longitudinal analysis of the data, so that the evolution of the policy can be assessed. The results of the study show that oral health indicators can be incorporated into the national NCD prevention and management systems, provided that institutional coordination, information systems, and equity considerations exist. This approach provides a structured basis for advancing integrated NCD monitoring frameworks.

Limitations of the Study

There are also limitations to the study that should be taken into consideration. First is the limited country sampling to six countries. As such, the generalizability to all health systems is limited. Second, the use of maximum variation sampling was employed to ensure the consideration of income level and NCD system maturity. However, the results may not fully represent settings with limited surveillance infrastructure and decentralized systems of government. Third, the use of the Oral Health-NCD Integration Index is limited to secondary data and document review. As such, the results may not fully represent informal reporting and undocumented coordination between institutions. Fourth, the study's results do not permit the consideration of temporal changes and the causal relationship between the structure and the integration outcome. Lastly, the results of the study using the Delphi method may have been influenced by the dominant policy approaches and perceptions of the experts involved.

V. Conclusion

This study illustrates the viability and policy salience of integrating oral health metrics into the broader non-communicable disease (NCD) prevention infrastructure in various countries through the application of a systematic and structured methodology. By engaging in this type of analysis,

which incorporates the validation of indicators through the Delphi method, cross-country assessment of the feasibility of such an integration, and implementation analysis, the study takes the discussion of the operational integration of oral and NCD prevention to the next level. It is evident from the results of this study that a limited set of oral health indicators can be operationalized within the existing NCD prevention infrastructure without the need to alter the existing infrastructure in its entirety. It is also evident from the results of this study that the success of such an integration is largely determined by the governance structure, the information technology infrastructure, and the formal inclusion of oral health into the NCD reporting infrastructure. What is perhaps most important is the fact that this study illustrates the notion that the operational integration of oral and NCD prevention is not limited by the epidemiologic complexities of the issue but rather the institutional complexities of the issue.

Future research should expand longitudinal and geographic scope to assess how integration evolves over time and how it influences population level health outcomes and resource allocation decisions. Additional country case studies, particularly in low and lower middle income settings, are needed to test scalability and contextual adaptability of the proposed Integration Index. Further work should also explore digital interoperability solutions that enable seamless linkage between oral health reporting platforms and national NCD dashboards. Finally, modeling studies examining long term health and economic returns of integrated monitoring could strengthen the evidence base for policy investment. Continued empirical investigation will be essential to consolidate oral health as a core, measurable component of comprehensive NCD prevention systems worldwide.

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