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## **ТИББИЁТДА ЯНГИ КУН НОВЫЙ ДЕНЬ В МЕДИЦИНЕ NEW DAY IN MEDICINE**

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ACCESS TO DENTAL CARE FOR VULNERABLE POPULATIONS: A COMPARATIVE DESCRIPTIVE STUDY USING SECONDARY DATA FROM GERMANY AND TAJIKISTAN

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✓ **Resume**

**Background:** Oral diseases affect approximately 3.5 billion people worldwide, yet access to dental care remains profoundly inequitable for vulnerable populations. Systematic comparative data on dental care access across contrasting health-system contexts are scarce. This study provides a structured comparison between Germany, a high-income country with comprehensive statutory dental coverage, and Tajikistan, a low-income post-Soviet transitional state with limited public dental infrastructure.

**Objectives:** To describe and compare access to dental care for persons living in poverty, asylum seekers and refugees, orphaned or institutionalised children, and persons with disabilities in Germany and Tajikistan, using publicly available secondary data and official health-system documentation.

**Methods:** Comparative descriptive ecological study based on retrospective analysis of aggregated data from international repositories (Global Burden of Disease 2021, WHO Global Health Observatory, World Bank) and national statistical sources. Two investigators independently extracted and harmonised data using a standardised protocol. Each indicator pair was assigned a comparability rating (high, moderate, limited, or not comparable). Analyses were primarily descriptive, including absolute differences, relative ratios, and narrative synthesis. Reporting followed STROBE, RECORD, and STROBE-Equity guidelines.

**Results:** Germany and Tajikistan exhibit marked structural disparities across the assessed outcome domains. Using the harmonised UNECE SDG 3.c.1 definition, Germany's dentist density (approximately 8.5 per 10,000 population) exceeded Tajikistan's (approximately 1.6 per 10,000) by a roughly fivefold ratio. Per capita dental expenditure was USD 372 in Germany versus USD 3.3 in Tajikistan (ratio approximately 113:1). Out-of-pocket health expenditure constituted 64.0% of current health spending in Tajikistan compared to 12.4% in Germany. Based on WHO Oral Health Country Profiles (GBD 2019), the prevalence of untreated caries of deciduous teeth was substantially higher in Tajikistan (48.3%) than Germany (29.1%), while untreated caries of permanent teeth was moderately higher in Tajikistan (35.0% vs 31.7%). Conversely, severe periodontitis (27.4% vs 10.8%) and edentulism (11.7% vs 8.6%) were higher in Germany, consistent with its older population structure. Subgroup-disaggregated oral health data for the four vulnerable populations of interest were largely unavailable in Tajikistan and only partially available in Germany. The systematic documentation of these data gaps constitutes a principal finding of this study.

**Conclusions:** Profound structural disparities in dental care capacity, financing, and data infrastructure exist between Germany and Tajikistan. The near-complete absence of subgroup-disaggregated oral health data for vulnerable populations in Tajikistan—and significant gaps even in Germany—represents a critical barrier to evidence-based equity-oriented policy. Future bilateral academic collaboration and targeted primary data collection are urgently needed.

**Keywords:** dental health services; health equity; vulnerable populations; comparative study; secondary data analysis; ecological study; Germany; Tajikistan; oral health; access to care

## Relevance

Oral diseases represent a major global public health challenge, affecting approximately 3.5 billion people worldwide, with untreated dental caries being the most prevalent condition across the life course [1]. The Global Burden of Disease (GBD) 2021 study estimated a combined global age-standardised prevalence of the main oral conditions (untreated caries, severe periodontitis, edentulism, and other oral disorders) of approximately 45,900 per 100,000 population, with only minor changes observed over the 1990–2021 period [1]. Despite advances in oral health knowledge and preventive strategies, access to dental care remains profoundly inequitable, particularly for vulnerable populations including persons living in poverty, asylum seekers and refugees, orphaned or institutionalised children, and persons with physical or mental disabilities [2–4].

Access to dental care is multidimensional and encompasses the availability, accessibility, affordability, acceptability, and appropriateness of services [5–8]. For vulnerable populations, barriers commonly operate simultaneously and may include cost, administrative obstacles, transportation, language, disability-related accessibility barriers, low service availability, and weak preventive infrastructure. These disparities persist across diverse health-system configurations, from high-income countries with comprehensive universal health coverage to low- and middle-income nations with limited public dental health infrastructure [9,10].

Germany and Tajikistan provide an analytically useful contrast for examining these disparities. Germany, the largest member state of the European Union by population (approximately 83.3 million in 2020), operates a Bismarckian social health insurance model with relatively comprehensive statutory dental coverage. Approximately 90% of the population is covered under statutory health insurance (Gesetzliche Krankenversicherung, GKV), which reimburses a legally prescribed standard oral healthcare package including routine preventive, restorative, and prosthodontic services [10,11]. Germany has a well-developed dental workforce, with approximately 8.6 dentists per 10,000 population and total dental healthcare expenditure estimated at approximately USD 30.9 billion (USD 372 per capita) in 2019 [WHO, 2022].

Tajikistan, by contrast, is a low-income, landlocked Central Asian republic (population approximately 9.5 million in 2020) with a transitional health system inherited from the Soviet era. The country's per capita health expenditure is among the lowest in the WHO European Region, estimated at 251 PPP international dollars in 2019 [WHO Oral Health Country Profile, 2022]. Out-of-pocket payments constitute 64% of current health expenditure, and public health expenditure represents only about 2% of GDP. The basic benefit package—launched in only 19 of 62 districts as of 2019—covers approximately 21% of the population [P4H Network, 2022]. The dental workforce, while constrained, maintains a density of approximately 1.5–1.7 dentists per 10,000 population according to the UNECE SDG 3.c.1 series, and per capita dental expenditure was estimated at a mere USD 3.3 in 2019 [WHO Oral Health Country Profile, 2022].

Despite the recognised importance of oral health equity, systematic comparative data on access to dental care for vulnerable populations across different health-system contexts remain limited [10,11]. Most existing comparative studies in oral health have focused on European or high-income country clusters, leaving a significant gap in the evidence base regarding comparisons between high-income and low-income health systems. This gap is compounded by substantial asymmetries in the availability, granularity, and methodological quality of oral health data between countries at different levels of economic development.

This study addresses this knowledge gap through a rigorous, protocol-driven secondary data analysis. Its primary objective is to describe and compare access to dental care for four specified vulnerable population groups in Germany and Tajikistan using publicly available data and official health-system documentation. In doing so, the study aims not only to identify substantive disparities in oral health indicators, workforce capacity, financial accessibility, and service utilisation, but also to systematically document data gaps as a structural finding in its own right—one that may inform future primary research and bilateral academic collaboration. The study is reported in accordance with the STROBE guidelines for observational studies [12], the RECORD extension for routinely collected health data [13,14], and STROBE-Equity principles [19].

## **2. Materials and Methods**

### **2.1 Study Design**

This is a comparative descriptive ecological study based on retrospective secondary analysis of aggregated data [20]. The study drew on international repositories, national statistical sources, official reports, and other publicly accessible institutional documents from Germany and Tajikistan. No primary data were collected and no individual-level patient records were used. The study was conducted in accordance with a pre-specified protocol (version dated 9 April 2026) registered on the Open Science Framework (OSF).

### **2.2 Data Sources**

Data were extracted from the following hierarchically prioritised sources:

#### **2.2.1 International Data Repositories**

The Global Burden of Disease (GBD) Study 2021, accessed via the Global Health Data Exchange (GHDx) platform, provided age-standardised prevalence estimates and disability-adjusted life-years (DALYs) for untreated caries (deciduous and permanent teeth), severe periodontitis, edentulism, and other oral disorders [1]. The WHO Global Health Observatory provided dentist density per 10,000 population and the Universal Health Coverage (UHC) service coverage index. World Bank Open Data provided GDP per capita (current USD and PPP-adjusted), out-of-pocket health expenditure as a proportion of current health expenditure, and poverty headcount ratios. OECD Health Statistics were used for Germany-specific indicators including health expenditure by function and unmet needs for dental care.

#### **2.2.2 Germany-Specific Sources**

The Federal Statistical Office (Destatis) and its Genesis-Online database provided sociodemographic, poverty-related, disability, and migration statistics. The Kassenzahnärztliche Bundesvereinigung (KZBV) annual statistical reports provided data on practising dentists by region, dental service utilisation rates, and insurance coverage. The Robert Koch Institute (RKI) surveys, including KiGGS (German Health Interview and Examination Survey for Children and Adolescents) and GEDA (Gesundheit in Deutschland aktuell), provided oral health and utilisation indicators. The Federal Office for Migration and Refugees (BAMF) provided asylum seeker demographics and migration statistics.

#### **2.2.3 Tajikistan-Specific Sources**

The Ministry of Health and Social Protection of the Republic of Tajikistan was consulted for annual health sector reports, national health accounts, dental workforce data, and medical statistics division reports. The Agency on Statistics under the President of the Republic of Tajikistan provided health and demographic yearbooks. The Tajikistan Demographic and Health Surveys (DHS 2012 and 2017) provided contextual health, equity, and socioeconomic information. UNICEF Tajikistan and the Multiple Indicator Cluster Surveys (MICS) provided data on child health indicators and disability prevalence estimates. The WHO Country Office for Tajikistan provided health system performance indicators and health financing data. Where Tajikistan-specific sources were published in Tajik or Russian, the Tajik co-investigators were responsible for identifying, translating, and contextualising relevant local documents, with key data points subject to back-translation verification.

### **2.3 Source Hierarchy and Selection Criteria**

Whenever multiple sources reported the same indicator, priority was given to the source with the clearest definition, the broadest national coverage, the most recent comparable year, and the strongest methodological documentation. For each extracted indicator, the study database retained the exact source, year, definition, denominator, and any reported uncertainty interval. In cases of inactive links or inaccessible national databases, alternative sources (e.g., WHO or World Bank country reports) were prioritised.

### **2.4 Population Groups of Interest (Equity Stratifiers)**

Four vulnerable population groups were defined as equity stratifiers, consistent with the protocol: (a) persons living in poverty, defined as individuals or households below nationally defined poverty thresholds or in lower-income strata; (b) asylum seekers and refugees, identified through official migration or refugee statistics (BAMF for Germany; UNHCR and national data for Tajikistan); (c) orphaned or institutionalised children aged 0–17 years; and (d) persons with physical or mental disabilities, as identified in official disability statistics or registries. These groups were treated as

population groups of interest and equity stratifiers, not as classical exposure variables. Where direct subgroup-disaggregated oral health data were unavailable, broader socioeconomic proxies (e.g., lowest wealth quintile, extreme rurality) were substituted and explicitly acknowledged. Where no quantitative proxy existed, the absence of the indicator was documented as a structural finding.

## **2.5 Outcome Domains**

Five outcome domains were assessed. Core Domain A (Oral Disease Burden) included age-standardised prevalence of untreated caries, severe periodontitis, and edentulism, as well as DALYs attributable to oral conditions. Core Domain B (Service Capacity) included dentists per 10,000 population, subnational workforce distribution, and the presence of paediatric dentistry or disability-adapted services. Core Domain C (Financial Accessibility) included out-of-pocket dental expenditure, insurance or entitlement coverage, dental-care cost barriers, and per capita dental expenditure. Core Domain D (Service Utilisation and Unmet Need) included annual dental visit rates, preventive-care utilisation, and self-reported or administratively documented unmet need. Extended Domain E (Vulnerable-Group Indicators) included subgroup-specific utilisation, entitlements, barriers, adapted services, or institutional arrangements—extracted only when disaggregated data were available.

## **2.6 Comparability Assessment**

For each Germany–Tajikistan indicator pair, a comparability rating was assigned during extraction: High (identical or near-identical definitions and collection methods; direct comparison appropriate), Moderate (similar definitions with documented differences; comparison with caveats), Limited (substantial definitional or methodological differences; only descriptive juxtaposition appropriate), or Not comparable (separate presentation for each country; no direct comparison attempted). This matrix is reported alongside all comparative results to ensure transparent interpretation.

## **2.7 Harmonisation Strategy**

Temporal alignment prioritised the most recent comparable period shared by both countries, preferably within the 2019–2023 window. When exact year matching was not possible, the nearest available year was used and clearly reported. Data heavily disrupted by the COVID-19 pandemic were explicitly contextualised. Age-standardised rates from source datasets were retained whenever directly available. Monetary indicators were reported in their original form and, where appropriate, converted using World Bank PPP conversion factors. Country-specific definitions that could not be fully harmonised were described transparently rather than forced into artificial comparability. Multiple imputation was not employed given the macro-level nature of the data; missing data were reported transparently.

## **2.8 Statistical Analysis**

Because the dataset consisted of aggregate indicators from heterogeneous sources, the analysis was primarily descriptive and comparative rather than inferential. The main analytical unit was the country–year–indicator combination. For each indicator, the study reports the value, year, source, and subgroup applicability. Between-country comparisons focused on absolute differences, relative ratios, and percentage differences for indicators rated as having high or moderate comparability. Inferential effect-size measures (e.g., Cohen’s *d*) were not used. Trend analysis was performed only for indicators with at least two comparable time points; percentage change was reported routinely. Equity analyses such as concentration indices or the slope index of inequality were planned only if adequate disaggregated data were available; otherwise, descriptive gap analyses and narrative policy comparison were substituted. When quantitative synthesis was not possible, a structured narrative synthesis was provided following the framework proposed by Popay et al. [21].

## **2.9 Reporting Standards**

The manuscript was reported in line with the STROBE statement for observational studies [12], the RECORD extension for routinely collected health data [13,14], and STROBE-Equity principles [19]. These guidelines were implemented in structure, transparency, limitations, and reporting logic throughout the manuscript.

## **2.10 Ethical Considerations**

This study used only publicly available, aggregated, non-identifiable data and involved no contact with human participants. It was anticipated to qualify for exemption from full ethical review. The study was conducted in compliance with the EU General Data Protection Regulation (GDPR), Tajikistan national data protection legislation, and institutional data security policies at both participating institutions. The protocol was registered on the Open Science Framework to prevent selective reporting.

### 3.1 Structured Evidence Matrix

Table 1, 1/1, 1/2, 1/3 presents the structured evidence matrix containing all extracted indicators, their values, sources, years, comparability ratings, and relevant caveats. This matrix was constructed prior to the narrative Results and serves as the evidence base for all subsequent description and comparison.

**Table 1. Comparative evidence matrix: oral health and access indicators, Germany and Tajikistan.**

| ID | Indicator                                                           | Germany Value | Year | Germany Source                             | Tajikistan Value | Year | Tajikistan Source                          | Comparability | Comments / Caveats                                                                                   |
|----|---------------------------------------------------------------------|---------------|------|--------------------------------------------|------------------|------|--------------------------------------------|---------------|------------------------------------------------------------------------------------------------------|
| A1 | Prevalence of untreated caries, permanent teeth (age-std., %, 5+ y) | 31.7          | 2019 | WHO Oral Health Country Profile (GBD 2019) | 35.0             | 2019 | WHO Oral Health Country Profile (GBD 2019) | High          | Same GBD modelling framework; model-based, not survey prevalence                                     |
| A2 | Prevalence of untreated caries, deciduous teeth (%, 1–9 y)          | 29.1          | 2019 | WHO Oral Health Country Profile (GBD 2019) | 48.3             | 2019 | WHO Oral Health Country Profile (GBD 2019) | High          | Same GBD framework; Tajikistan value substantially higher                                            |
| A3 | Prevalence of severe periodontitis (%, 15+ y)                       | 27.4          | 2019 | WHO Oral Health Country Profile (GBD 2019) | 10.8             | 2019 | WHO Oral Health Country Profile (GBD 2019) | Moderate      | Same GBD framework but highly sensitive to demographic age structure and tooth retention patterns    |
| A4 | Prevalence of edentulism (%, 20+ y)                                 | 11.7          | 2019 | WHO Oral Health Country Profile (GBD 2019) | 8.6              | 2019 | WHO Oral Health Country Profile (GBD 2019) | Moderate      | Same GBD framework but reflects cumulative lifetime disease and older demographic profile in Germany |

*Note: Where indicator values could not be identified from publicly accessible sources, they are reported as 'Data not available' and documented as a structural finding reflecting the state of national health information systems. No values were imputed or fabricated. The full extraction codebook is deposited as supplementary material on the Open Science Framework.*

**Table 1/1. Comparative evidence matrix: oral health and access indicators, Germany and Tajikistan.**

| ID | Indicator                                                | Germany Value                       | Year      | Germany Source                  | Tajikistan Value   | Year  | Tajikistan Source               | Comparability | Comments / Caveats                        |
|----|----------------------------------------------------------|-------------------------------------|-----------|---------------------------------|--------------------|-------|---------------------------------|---------------|-------------------------------------------|
| A5 | DALYs from oral conditions (age-std. rate per 100,000)   | Data not available                  | 2021      | GBD 2021                        | Data not available | 2021  | GBD 2021                        | High          | Same GBD framework                        |
| B1 | Dentists per 10,000 population                           | 8.5                                 | 2018–2019 | UNECE SDG 3.c.1 / WHO NHWA      | ~1.5–1.7           | 2010s | UNECE SDG 3.c.1                 | High          | Harmonised ISCO-08 definition; ~5:1 ratio |
| B2 | Total number of dentists                                 | 71,039 (2018); 72,767 active (2022) | 2018/2022 | WHO NHWA / gbe-bund.de          | Data not available | –     | MoH Tajikistan                  | Limited       | Scope and registration criteria differ    |
| B3 | Dental assistants/therapists per 10,000                  | 27.1                                | 2017      | WHO NHWA                        | Data not available | –     | WHO NHWA                        | Limited       | Category definitions vary                 |
| C1 | Per capita dental expenditure (USD)                      | 372                                 | 2019      | WHO Oral Health Country Profile | 3.3                | 2019  | WHO Oral Health Country Profile | High          | Same WHO methodology; ratio ~113:1        |
| C2 | Total dental expenditure (million USD)                   | 30,877                              | 2019      | WHO Country Profile             | Data not available | –     | WHO Country Profile             | Limited       |                                           |
| C3 | OOP health expenditure (% of current health expenditure) | 12.4%                               | 2021      | World Bank / WHO GHED           | 64.0%              | 2021  | WHO/P4H Network                 | High          | Same WHO SHA 2011 framework; ~5:1 ratio   |
| C4 | Current health expenditure (% of GDP)                    | 12.8                                | 2022      | World Bank                      | 7.6                | 2022  | World Bank                      | High          | Same framework                            |
| C5 | GDP per capita, current USD                              | 48,718                              | 2022      | World Bank                      | 1,054              | 2022  | World Bank                      | High          | Same framework; ratio ~46:1               |

*Note: Where indicator values could not be identified from publicly accessible sources, they are reported as ‘Data not available’ and documented as a structural finding reflecting the state of national health information systems. No values were imputed or fabricated. The full extraction codebook is deposited as supplementary material on the Open Science Framework.*



**Table 1/2. Comparative evidence matrix: oral health and access indicators, Germany and Tajikistan.**

| ID | Indicator                                                | Germany Value                                  | Year | Germany Source            | Tajikistan Value                               | Year | Tajikistan Source               | Comparability  | Comments / Caveats                                                                                |
|----|----------------------------------------------------------|------------------------------------------------|------|---------------------------|------------------------------------------------|------|---------------------------------|----------------|---------------------------------------------------------------------------------------------------|
| C6 | GDP per capita, PPP (int\$)                              | ~63,100                                        | 2022 | World Bank                | ~4,400                                         | 2022 | World Bank                      | High           | Same framework                                                                                    |
| C7 | Per capita health expenditure, PPP (int\$)               | 6,739                                          | 2019 | WHO GHO / Country Profile | 251                                            | 2019 | WHO Oral Health Country Profile | High           | Same WHO framework; ~27:1 ratio                                                                   |
| C8 | Population covered by main government scheme (%)         | ~90 (SHI)                                      | 2021 | WHO Country Profile       | ~21 (BBP)                                      | 2019 | P4H Network                     | Limited        | Entirely different coverage models                                                                |
| D1 | Annual dental consultations per capita                   | ~1.4                                           | 2022 | Statista / KZBV           | Data not available                             | —    | —                               | Not comparable |                                                                                                   |
| D2 | Unmet need for dental care due to cost (%)               | 0.6% (overall); 1.0% in lowest income quintile | 2022 | OECD Health Statistics    | Data not available                             | —    | —                               | Not comparable | No comparable survey in Tajikistan; Germany shows 5x gradient between lowest and highest quintile |
| E1 | Oral health data for persons in poverty                  | Partial (KiGGS social gradient data)           | —    | RKI                       | Not available (DHS wealth quintile proxy only) | —    | DHS Tajikistan                  | Limited        | Different constructs                                                                              |
| E2 | Oral health data for asylum seekers/refugees             | Very limited, fragmented studies               | —    | BAMF; grey literature     | Not available                                  | —    | —                               | Not comparable | Major data gap both countries                                                                     |
| E3 | Oral health data for orphaned/institutionalised children | Very limited                                   | —    | Grey literature           | Not available                                  | —    | UNICEF/MICS (contextual only)   | Not comparable | Major data gap                                                                                    |

*Note: Where indicator values could not be identified from publicly accessible sources, they are reported as 'Data not available' and documented as a structural finding reflecting the state of national health information systems. No values were imputed or fabricated. The full extraction codebook is deposited as supplementary material on the Open Science Framework.*

**Table 1/3. Comparative evidence matrix: oral health and access indicators, Germany and Tajikistan.**

| ID    | Indicator                                          | Germany Value                         | Year | Germany Source            | Tajikistan Value   | Year | Tajikistan Source    | Comparability  | Comments / Caveats                                        |
|-------|----------------------------------------------------|---------------------------------------|------|---------------------------|--------------------|------|----------------------|----------------|-----------------------------------------------------------|
| E4    | Oral health data for persons with disabilities     | Very limited                          | –    | Destatis; grey literature | Not available      | –    | –                    | Not comparable | Major data gap                                            |
| CT X1 | Population (thousands, 2020)                       | 83,329                                | 2020 | UN DESA                   | 9,538              | 2020 | UN DESA              | High           |                                                           |
| CT X2 | Poverty headcount ratio (national poverty line, %) | ~14.8 (at-risk-of-poverty)            | 2022 | Destatis / Eurostat       | ~26–27             | 2023 | World Bank           | Limited        | Different poverty definitions                             |
| CT X3 | UHC service coverage index                         | ~83                                   | 2021 | WHO GHO                   | ~63                | 2021 | WHO GHO              | High           | Same WHO methodology                                      |
| CT X4 | Urbanisation rate (%)                              | ~77                                   | 2022 | World Bank                | ~28                | 2022 | World Bank           | High           |                                                           |
| CT X5 | Number of asylum seekers (annual applications)     | ~244,000                              | 2022 | BAMF                      | Data not available | 2022 | UNHCR                | Limited        | Different legal frameworks; Tajikistan hosts few refugees |
| CT X6 | Disability prevalence (% of population)            | ~9.4 (severe disability card holders) | 2021 | Destatis                  | Data not available | –    | Agency on Statistics | Limited        | Entirely different registration systems                   |

*Note: Where indicator values could not be identified from publicly accessible sources, they are reported as ‘Data not available’ and documented as a structural finding reflecting the state of national health information systems. No values were imputed or fabricated. The full extraction codebook is deposited as supplementary material on the Open Science Framework.*

### 3.2 Contextual Overview

Germany and Tajikistan differ profoundly in their socioeconomic and health-system contexts. Germany’s GDP per capita (USD 48,718 in 2022) exceeds that of Tajikistan (USD 1,054) by a ratio of approximately 46:1. In purchasing power parity terms, the gap narrows but remains substantial (approximately 14:1). Current health expenditure as a proportion of GDP was 12.8% in Germany and 7.6% in Tajikistan in 2022 (World Bank). However, the per capita health expenditure in PPP international dollars was 6,739 in Germany versus 251 in Tajikistan—a ratio exceeding 27:1. Germany’s population is predominantly urbanised (approximately 77%), whereas Tajikistan’s remains predominantly rural (approximately 72%). The WHO UHC service coverage index was approximately 83 in Germany and approximately 63 in Tajikistan in 2021.

### 3.3 Domain A: Oral Disease Burden

According to the WHO Oral Health Country Profile for Germany (based on GBD 2019 estimates), the prevalence of untreated caries of permanent teeth among persons aged five years and older was 31.7%, the prevalence of untreated caries of deciduous teeth among children aged 1–9 years was 29.1%,

the prevalence of severe periodontal disease among persons aged 15 years and older was 27.4%, and the prevalence of edentulism among persons aged 20 years and older was 11.7%. These estimates derive from the GBD modelling framework (DisMod-MR 2.1) and carry 95% uncertainty intervals as published in the GBD 2021 appendix [1].

For Tajikistan, the WHO Oral Health Country Profile (based on GBD 2019 estimates) reports a prevalence of untreated caries of deciduous teeth of 48.3% among children aged 1–9 years—substantially higher than Germany’s 29.1% (absolute difference: 19.2 percentage points; ratio: 1.66:1). The prevalence of untreated caries of permanent teeth among persons aged 5 years and older was 35.0% in Tajikistan versus 31.7% in Germany (absolute difference: 3.3 percentage points; ratio: 1.10:1)—a smaller gap. Conversely, the prevalence of severe periodontal disease among persons aged 15 years and older was estimated at 10.8% in Tajikistan, compared with 27.4% in Germany. The prevalence of edentulism among persons aged 20 years and older was 8.6% in Tajikistan versus 11.7% in Germany. These latter two findings—higher periodontitis and edentulism prevalence in Germany—are likely attributable to Germany’s substantially older population structure rather than to better oral health in Tajikistan, and are consistent with known age-related patterns of these conditions. All estimates derive from the same GBD modelling framework and carry 95% uncertainty intervals as published in the GBD appendices [1]. Comparability is rated High for all Domain A indicators.

The comparability of GBD-derived oral disease burden estimates between Germany and Tajikistan is rated as High, because both countries’ estimates originate from the same modelling framework, the same case definitions, and the same analytical pipeline. However, the reliability of the underlying input data differs substantially: Germany contributes a richer body of epidemiological survey data to the GBD modelling process than does Tajikistan, where oral health surveys are sparse and primarily local.

### **3.4 Domain B: Service Capacity**

Germany has one of the densest dental workforces in the world. According to the WHO National Health Workforce Accounts (NHWA), Germany had 71,039 dentists in 2018, corresponding to a density of 8.6 dentists per 10,000 population. In addition, Germany reported 226,200 dental assistants and therapists (27.1 per 10,000) and 68,000 dental prosthetic technicians (8.1 per 10,000). More recent data from Statista (citing gbe-bund.de) indicate that there were 101,344 dentists in Germany in 2022, of whom 72,767 were actively employed. General dental practitioners in private practice provide almost all oral healthcare under the health insurance scheme [11].

For Tajikistan, the UNECE SDG 3.c.1 indicator series reports a dentist density fluctuating around 1.4–1.7 per 10,000 population over the 2010s, with the most recent available values around 1.5–1.6 per 10,000. Given the harmonised ISCO-08 definition (code 2261) and national coverage, comparability for this indicator is rated High. These figures indicate a roughly fivefold higher dentist density in Germany (approximately 8.5 per 10,000) than in Tajikistan (approximately 1.5–1.7 per 10,000), implying substantial differences in potential service availability at the population level. However, even Tajikistan’s reported density is higher than in many low-income countries globally, where over 37% of WHO Member States report fewer than 1 dentist per 10,000 population.

The Germany–Tajikistan ratio in dentist density, using the harmonised UNECE SDG 3.c.1 series, is approximately 5:1. While this is a substantial disparity, it is notably smaller than the gap in economic indicators (GDP per capita ratio of approximately 47:1) or health expenditure per capita (ratio of approximately 27:1), suggesting that Tajikistan has maintained a relatively higher dental workforce relative to its economic capacity. The comparability of this indicator is rated as High given the shared ISCO-08 definition, though registration practices and the distinction between active and registered dentists may differ between the two countries.

No data on subnational dental workforce distribution, paediatric dentistry capacity, or disability-adapted dental services were identified for Tajikistan in publicly available sources. For Germany, the KZBV provides regional data on dental practices and practitioners, showing variation across federal states (Länder), but detailed analysis of within-country equity in dental workforce distribution is beyond the scope of the present aggregate-level analysis.

### **3.5 Domain C: Financial Accessibility and Protection**

Financial accessibility to dental care differs dramatically between the two countries. In Germany, the statutory health insurance system covers routine and preventive oral health care, essential curative care, advanced curative care, and rehabilitation oral health care for approximately 90% of the population [WHO Country Profile, 2022]. Per capita dental expenditure was estimated at USD 372 in 2019, and

total national dental expenditure at approximately USD 30.9 billion. Fluoride toothpaste was classified as affordable (0.1 labour days needed to purchase an annual supply) [WHO Country Profile, 2022]. Notably, Germany's system includes a hardship provision (Härtefallregelung) covering 100% of standard prosthetic costs for low-income insured persons.

For Tajikistan, the WHO Oral Health Country Profile estimated per capita outpatient dental expenditure at a mere USD 3.3 in 2019—yielding a Germany-to-Tajikistan per capita dental expenditure ratio of approximately 113:1. This represents one of the most extreme disparities identified in this study and reflects the profoundly different fiscal environments for dental care. Furthermore, the WHO country profiles noted that oral health screening, urgent treatment for pain relief, and basic restorative dental procedures were classified as 'generally not available' in Tajikistan's public primary care facilities—in stark contrast to Germany, where all three service categories were classified as 'available'.

For Tajikistan, general health financing data reveal that current health expenditure as a percentage of GDP was 7.6% in 2022 (World Bank), with out-of-pocket health expenditure constituting 64.0% of current health expenditure in 2021 (WHO/P4H Network)—among the highest rates in the WHO European Region, and public health expenditure representing only about 2% of GDP. By contrast, out-of-pocket expenditure constituted 12.4% of current health expenditure in Germany. This comparison (rated High comparability, as both values derive from the WHO System of Health Accounts 2011 framework) highlights a roughly fivefold difference in the out-of-pocket burden. The per capita health expenditure was 251 PPP international dollars in Tajikistan versus 6,739 PPP international dollars in Germany (ratio approximately 27:1), indicating a dramatically different fiscal environment for health services, including dental care.

The basic benefit package in Tajikistan, launched in 19 of 62 districts as of 2019, entitles residents to emergency care, preventive and primary care, basic diagnostic testing, and specialist consultations upon referral at no charge. However, the package requires copayments of 50% with referral and up to 70% without referral for other services. Vulnerable populations, including low-income persons and infants, are nominally exempt from user fees. The extent to which dental services are explicitly included within this package—and the degree to which fee exemptions are effectively implemented in practice—could not be ascertained from publicly available documentation and warrants further investigation.

### **3.6 Domain D: Service Utilisation and Unmet Need**

In Germany, the number of annual dentist consultations per capita was approximately 1.4 in 2022. A 2018 survey indicated that 86% of German respondents reported visiting the dentist at least once per year, with 41% attending twice yearly. According to OECD Health Statistics (2022), self-reported unmet need for dental care due to cost was 0.6% in Germany overall—low by international standards but with a notable socioeconomic gradient: unmet dental need was approximately 1.0% in the lowest income quintile compared to 0.2% in the highest, representing a fivefold within-country equity gap even in a well-resourced system.

For Tajikistan, no comparable population-level data on annual dental visit rates or unmet need for dental care were identified in publicly available international databases. The DHS Tajikistan surveys (2012, 2017) do not include specific questions on dental service utilisation. This indicator pair is rated as Not comparable, and results are presented separately.

### **3.7 Domain E: Vulnerable-Group Indicators**

The assessment of oral health indicators specific to the four vulnerable population groups of interest (persons in poverty, asylum seekers and refugees, orphaned or institutionalised children, and persons with disabilities) revealed the most pronounced data gaps of the entire study. These findings are presented by population group below.

#### **3.7.1 Persons Living in Poverty**

For Germany, the RKI's KiGGS study has documented social gradients in children's oral health, with lower socioeconomic status associated with higher caries prevalence and lower utilisation of preventive dental services. However, nationally representative data linking poverty status to adult oral health indicators at the population level are limited. The poverty-at-risk rate in Germany was approximately 14.8% in 2022 (Destatis/Eurostat), using the EU standard of 60% of median equivalised income.

For Tajikistan, the poverty headcount ratio at the national poverty line was approximately 26–27% in 2023 (World Bank). However, no oral health data disaggregated by poverty status or income level were identified. The DHS Tajikistan provides wealth quintile data that could serve as a proxy stratifier

for general health indicators, but oral health is not among the outcomes measured in the DHS. This represents a critical data gap. Comparability: Limited (different poverty definitions, no common oral health outcome).

### **3.7.2 Asylum Seekers and Refugees**

Germany received approximately 244,000 asylum applications in 2022 (BAMF). Under the Asylbewerberleistungsgesetz (AsylbLG, Asylum Seekers' Benefits Act), asylum seekers in the first 18 months of residency have access only to emergency and essential medical care, including dental care limited to acute pain relief and essential treatment. Comprehensive statutory health insurance coverage is typically not available during this period. Several small-scale studies have documented poor oral health status and significant unmet dental needs among asylum seekers and refugees in Germany [5–7], but nationally representative data on this population's oral health are not available.

For Tajikistan, UNHCR data on refugees and asylum seekers would be the primary source; however, Tajikistan hosts a relatively small number of refugees. No oral health data specific to this population were identified. Comparability: Not comparable (fundamentally different migration contexts and data availability).

### **3.7.3 Orphaned or Institutionalised Children**

For Germany, no nationally representative oral health data specific to orphaned or institutionalised children were identified in the sources reviewed. For Tajikistan, UNICEF and MICS data provide estimates of orphan prevalence and children in institutional care, but these do not include oral health outcomes. This constitutes a data gap in both countries. Comparability: Not comparable.

### **3.7.4 Persons with Disabilities**

In Germany, approximately 9.4% of the population held a severe disability card (Schwerbehindertenausweis) in 2021 (Destatis). Dental treatment for persons with severe disabilities is available under the statutory health insurance system, and additional provisions exist for patients who require treatment under general anaesthesia. However, nationally representative data on oral health outcomes or dental care utilisation specific to persons with disabilities are limited.

For Tajikistan, disability prevalence estimates from official statistics require extraction from the Agency on Statistics. No oral health data disaggregated by disability status were identified. Comparability: Not comparable (entirely different disability classification and registration systems).

## **3.8 Summary of Data Gaps**

The systematic documentation of data gaps is a principal finding of this study. Table 2 summarises the most critical gaps identified across the five outcome domains.

*Table 2. Summary of critical data gaps by outcome domain.*

| Domain               | Germany                                                                      | Tajikistan                                                                                                 | Implication                                                                  |
|----------------------|------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| A: Disease burden    | GBD estimates available; limited direct survey data for vulnerable subgroups | GBD modelled estimates available but based on sparse input data; no national oral health survey identified | Tajikistan GBD estimates carry wider uncertainty                             |
| B: Service capacity  | Comprehensive KZBV data; subnational distribution available                  | Very limited publicly available data; precise dentist count unverifiable from international sources        | Comparison relies on potentially outdated estimates                          |
| C: Financial access  | Detailed; dental expenditure estimates available                             | No dental-specific expenditure data; high OOP share documented for general health                          | Dental-specific financial comparison not possible                            |
| D: Utilisation       | KZBV and survey data available; EU-SILC unmet need                           | No population-level dental utilisation data identified                                                     | Utilisation comparison not possible                                          |
| E: Vulnerable groups | Partial data for poverty gradient (KiGGS); fragmented for other groups       | No subgroup-disaggregated oral health data identified for any of the four groups                           | The central equity question cannot be answered quantitatively for Tajikistan |

## 4. Discussion

This comparative descriptive ecological study systematically examined access to dental care for vulnerable populations in Germany and Tajikistan using publicly available secondary data. The findings reveal profound structural disparities in dental care capacity, financing, and data infrastructure between the two countries, and highlight the near-complete absence of subgroup-disaggregated oral health data for vulnerable populations—a finding that is, itself, of considerable policy relevance.

### 4.1 Interpretation of Main Findings

The most consistent quantitative finding is the magnitude of the gap in dental workforce capacity and health financing. Germany's dentist density of approximately 8.5 per 10,000 population exceeds Tajikistan's approximately 1.5–1.7 per 10,000 by a roughly fivefold ratio, using the harmonised UNECE SDG 3.c.1 definition. The approximately fivefold difference in out-of-pocket health expenditure burden between the two countries further suggests that financial barriers to dental care in Tajikistan are substantially more severe. Notably, the oral disease burden comparison yields a more nuanced picture: while untreated caries of deciduous teeth is substantially more prevalent in Tajikistan (48.3% vs 29.1%), severe periodontitis (10.8% vs 27.4%) and edentulism (8.6% vs 11.7%) are paradoxically lower in Tajikistan than in Germany. These patterns are best interpreted in light of Germany's substantially older population structure, given the strong age-dependence of periodontitis and tooth loss, and do not necessarily indicate better oral health in Tajikistan. The age-standardised GBD estimates partially control for demographic structure, but residual confounding by population age composition cannot be excluded in prevalence estimates that use broad age thresholds.

The GBD-based disease burden estimates, while derived from the same modelling framework, must be interpreted with caution in the case of Tajikistan. The GBD relies heavily on model-based estimation for countries with sparse oral health survey data. For Tajikistan, the number of input data points feeding into the DisMod-MR 2.1 model for oral conditions is likely to be very limited, meaning that the country-level estimates carry wider uncertainty intervals and may reflect regional borrowing of epidemiological parameters from neighbouring countries. This does not invalidate the estimates, but it underscores the need for primary oral health surveys in Tajikistan to improve the empirical foundation of these modelled estimates.

### 4.2 Health-System Structural Factors

The contrasting health-system architectures of Germany and Tajikistan help explain the observed disparities. Germany's Bismarckian social insurance model, with its long history dating to the nineteenth century, provides near-universal coverage for a comprehensive dental benefit package including preventive, restorative, and prosthodontic care. The regulatory and financing infrastructure supporting dental care in Germany—including the KZBV, the statutory health insurance funds, and the system of contract dentistry—represents a mature institutional framework with well-established data collection and reporting mechanisms.

Tajikistan's post-Soviet health system, by contrast, has undergone significant restructuring since independence in 1991. The transition from a centralised Semashko model to a mixed system with substantial out-of-pocket financing has been accompanied by a reduction in publicly funded health services, including dental care. The basic benefit package, still in pilot phase in fewer than one-third of districts as of 2019, represents an important but incomplete step toward financial protection. The extent to which dental services are meaningfully included within this package—and accessible in practice—remains unclear from available documentation.

### 4.3 Data Asymmetry as a Structural Finding

Perhaps the most important finding of this study is the documentation of systematic data asymmetry between the two countries. For Germany, a relatively rich data infrastructure exists—encompassing GBD estimates, KZBV administrative data, RKI survey data (KiGGS, GEDA), Destatis demographic and disability data, BAMF migration data, and EU-wide harmonised survey instruments (EU-SILC). Even so, nationally representative oral health data disaggregated for specific vulnerable populations (asylum seekers, orphaned children, persons with disabilities) remain limited and fragmented.

For Tajikistan, the data infrastructure for oral health is dramatically more limited. No national oral health survey was identified; the GBD relies on modelled estimates with sparse local input data; dental workforce and expenditure data are difficult to verify from international sources; and no subgroup-disaggregated oral health data for any of the four vulnerable populations of interest were identified. This absence of data is not merely a methodological limitation—it reflects the structural underdevelopment

of oral health information systems in the country and represents a barrier to evidence-based policy that is at least as important as the substantive disparities in disease burden and service capacity.

#### **4.4 Ecological Fallacy and Limitations of Inference**

A fundamental limitation of this study, inherent to its ecological design, is the risk of ecological fallacy [22]. Country-level aggregate data on dental workforce density, disease prevalence, or out-of-pocket expenditure do not permit inferences about individual-level determinants of access to dental care. A person with a disability living in a German city with high dentist density may nonetheless face severe barriers to dental care that are invisible in aggregate statistics. Conversely, aggregate indicators of low workforce density in Tajikistan do not preclude the existence of pockets of adequate dental care in urban centres such as Dushanbe. The findings of this study describe system-level patterns, not individual-level experiences or causal pathways.

#### **4.5 Comparison with Existing Literature**

The findings of this study are broadly consistent with the existing comparative literature on oral health systems. Henschke et al. (2023), in a five-country comparison of oral health status and coverage, documented substantial cross-country variation in oral healthcare coverage, financing, and unmet need, and highlighted the role of health-system design in shaping equitable access [10]. Sonmez and Sonmez (2026) have argued for the integration of oral health into universal health coverage frameworks in Europe, a recommendation that is strongly supported by the Tajikistan findings of the present study [9]. The GBD 2021 Oral Disorders Collaborators (2025) noted that the European region was the only WHO region with decreasing age-standardised prevalence of untreated caries, but cautioned that progress has been slow and unevenly distributed [1]. Studies specifically examining oral health among refugees and asylum seekers in high-income countries [5–8] have consistently documented high caries prevalence, unmet treatment needs, and systemic barriers to care—findings that contextualise the gaps identified in this study for Germany.

### **5. Strengths and Limitations**

#### **5.1 Strengths**

This study has several notable strengths. First, it follows a registered protocol with a clearly specified analytical framework, enhancing transparency and reducing the risk of selective reporting. Second, the use of a formal comparability assessment matrix for each indicator pair ensures that the degree of confidence warranted by each comparison is explicitly communicated to the reader. Third, the systematic documentation of data gaps as a study output in its own right adds value beyond what a conventional comparative analysis would provide. Fourth, the study draws on the most authoritative international data sources (GBD, WHO, World Bank) and national institutional sources, prioritising methodological quality and verifiability. Fifth, the reporting adheres to STROBE, RECORD, and STROBE-Equity guidelines, ensuring that the health-equity focus is structurally embedded in the manuscript.

#### **5.2 Limitations**

The study has important limitations that must be acknowledged. First, the ecological study design does not permit individual-level causal inference; findings describe population-level patterns only [22]. Second, data availability was profoundly asymmetric between the two countries, with Tajikistan contributing substantially less granular and less verifiable data across all five outcome domains. This asymmetry means that many comparisons could not be performed quantitatively and were replaced with narrative synthesis or presented as documented data gaps. Third, some indicators for Tajikistan rely on estimates whose recency and coverage could not be independently verified from publicly accessible international sources. Fourth, the GBD estimates for Tajikistan are modelled with sparse input data and carry wider uncertainty intervals than those for Germany. Fifth, temporal misalignment between indicators (e.g., different reference years for the two countries) introduces imprecision, though this was mitigated by the harmonisation strategy. Sixth, the COVID-19 pandemic may have disrupted data collection and dental service delivery in both countries during 2020–2021, though the impact on aggregate indicators is not precisely quantifiable. Seventh, subgroup-disaggregated oral health data for the four vulnerable populations of interest were largely unavailable, meaning that the central equity question of the study could be addressed qualitatively and structurally but not through direct quantitative subgroup comparison. Eighth, the protocol envisaged trend analyses (joinpoint or annual percentage change methods) and sensitivity analyses; however, sufficiently dense and definitionally stable time-

series data were not available for any indicator in both countries simultaneously, and these analyses could therefore not be executed.

## **6. Policy Implications**

### **6.1 Implications for Germany**

Despite its strong dental infrastructure, Germany faces persistent equity gaps in dental care access for vulnerable populations. The restriction of dental entitlements for asylum seekers under the AsylbLG to emergency and essential care during the first 18 months represents a statutory barrier to comprehensive oral healthcare. Expanding dental coverage for asylum seekers, strengthening data collection on oral health among persons with disabilities and institutionalised children, and enhancing the routine disaggregation of oral health indicators by socioeconomic status in national health surveys (e.g., future waves of KiGGS and GEDA) would strengthen the evidence base for equity-oriented dental policy.

### **6.2 Implications for Tajikistan**

Tajikistan faces fundamental challenges in dental care infrastructure, financing, and data systems. The findings of this study suggest several policy priorities: (a) investment in dental workforce development, including training, recruitment, and equitable geographic distribution; (b) progressive inclusion of essential dental services within the basic benefit package as it expands to additional districts; (c) establishment of a national oral health survey to provide baseline data on disease burden, service utilisation, and equity gaps; and (d) strengthening of health information systems to enable routine collection and reporting of dental health indicators, disaggregated by relevant equity stratifiers.

### **6.3 Implications for Comparative Oral Health Equity Research**

This study demonstrates both the feasibility and the limitations of comparative secondary data analysis for oral health equity across countries at very different levels of economic development. The analytical framework—including the comparability assessment matrix, the five-domain indicator structure, and the systematic documentation of data gaps—may be transferable to other comparative contexts, such as other Bismarckian insurance-based systems versus other post-Soviet transitional health systems. However, the findings also underscore that meaningful comparative equity analysis depends critically on the availability of disaggregated data, and that the absence of such data in one or both comparator countries fundamentally constrains the conclusions that can be drawn.

### **6.4 Implications for Bilateral Academic Collaboration**

The collaboration between MVZ Kinderzahnarztpraxis Konstanz MediLink GmbH (Germany) and Avicenna Tajik State Medical University (Tajikistan) represents a model for North–South academic partnerships in dental public health. Future collaborative priorities should include: (a) conducting a joint primary data collection study on oral health status and access among vulnerable populations in Tajikistan, using standardised WHO oral health survey instruments; (b) capacity building for health information systems and oral health surveillance in Tajikistan; (c) collaborative development of policy briefs for the respective ministries of health; and (d) joint grant applications to international funding bodies (e.g., WHO, EU research programmes, bilateral development agencies) to support sustained collaborative research.

## **7. Conclusions**

This comparative descriptive ecological study has characterised divergent mechanisms driving oral health inequity across two fundamentally distinct health-system architectures. In Tajikistan, critical shortages in the dental workforce (approximately fivefold lower density than Germany), extremely limited per capita dental expenditure (USD 3.3 vs USD 372; a 113:1 ratio), and an overwhelming reliance on out-of-pocket payments (64.0% of current health spending) create immense structural and financial barriers to care, particularly for the poorest populations. In Germany, comprehensive infrastructure and financial pooling mitigate absolute deficits, yet targeted legislative exclusions—most notably the restriction of dental care for asylum seekers under the Asylbewerberleistungsgesetz—demonstrate that systemic capacity alone does not guarantee equitable access. Crucially, neither country systematically produces the subgroup-disaggregated oral health data required to monitor equity for persons in poverty, refugees, institutionalised children, or persons with disabilities; this data asymmetry, documented here as a principal structural finding, represents an urgent priority for both national health information systems and future bilateral academic collaboration.

## 8. Ethics Statement

This study used only publicly available, aggregated, non-identifiable data and involved no contact with human participants. The study was conducted in compliance with the EU General Data Protection Regulation (GDPR), Tajikistan national data protection legislation, and institutional data security policies at both participating institutions. The protocol was registered on the Open Science Framework (OSF).

## 9. Data Availability Statement

All data used in this study were derived from publicly available sources. Extracted datasets, the codebook, and statistical code will be deposited on the Open Science Framework (OSF) repository upon publication. The sources for all indicators are detailed in the evidence matrix (Table 1) and the reference list.

## 10. Conflict of Interest Statement

The authors declare no conflicts of interest.

## 11. Author Contributions

GEV: Conceptualisation, Methodology, Formal Analysis, Writing – Original Draft, Writing – Review and Editing, Supervision, Project Administration. CV: Conceptualisation, Methodology, Writing – Review and Editing. [Tajik co-investigator name(s)]: Resources, Data Curation, Validation, Writing – Review and Editing. All authors have read and approved the final version of the manuscript.

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