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Clinical Decision-Making of Repair vs. Replacement of Defective Direct Dental Restorations: A Multinational Cross-Sectional Study With Meta-Analysis

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ABSTRACT

Objectives: This web-based survey, conducted across multiple countries, sought to explore the factors that impact the decision-making of clinicians when it comes to managing defective direct restorations.

Methods: A survey consisting of 14 questions was sent out to dentists in 21 countries through various online platforms. The survey consisted of two sections. The first contained five questions about demographic information, while the second involved eight

clinical scenarios. In the second part, participants were tasked with deciding whether to repair or replace defective composite and amalgam restorations.

Results: Three thousand six hundred eighty dental practitioners completed the survey. For composite restorations, repair was preferred in scenarios like partial loss or fracture (RR:0.72; 95% CI: 0.58, 0.89; $p = 0.002$), whereas replacement was favored for secondary caries (RR:2.43; 95% CI: 1.87, 3.16; $p < 0.001$) and open/defective margins (RR:3.93; 95% CI: 2.68, 5.76;$p < 0.001$). Amalgam restorations were mostly replaced across all scenarios. The main factors influencing decision-making were caries risk, restoration size, and patient oral hygiene. Substantial heterogeneity was observed across countries.

Conclusion: This study underscores the complexity of the decision-making process and the need for evidence-based guidelines to inform clinicians' decisions regarding restoration management. Patient-level factors predominantly influence decision-making, emphasizing the need for individualized approaches.

Clinical Significance: The study reveals that the material type in the original restoration is a critical determinant, with composite restorations being repaired in specific scenarios, while amalgam restorations are consistently replaced across different countries. Key patient and tooth-level factors, such as high caries risk, poor oral hygiene, and restoration size, significantly impact clinicians' decisions, often favoring replacement over repair. These findings underscore the necessity for evidence-based guidelines to assist clinicians in making informed choices, ultimately enhancing the quality of patient care.

1 | Introduction

Dental amalgam and resin composite are widely utilized as direct-placement materials for dental restorations on a global scale [1, 2]. With a limited lifespan, dental restorations have garnered significant attention, comprising up to 60% of general dentistry procedures [3–6]. When faced with defective restorations, clinicians are confronted with a pivotal decision—whether to repair the existing one or proceed with replacement. The decision between repair and replacement is not merely a technical choice but has significant implications for patient care and dental practice management. On a practical level, the choice impacts the longevity of the restoration, the preservation of healthy tooth structure, and the overall treatment cost for the patient. Clinically, an inappropriate decision may lead to overtreatment or undertreatment, both of which can have adverse effects on patient outcomes. For instance, unnecessary replacement of a restoration can accelerate the "restorative death spiral," where successive replacements lead to cumulative loss of tooth structure and ultimately tooth failure [7]. Conversely, failure to repair a defective restoration promptly might result in further deterioration and more complex future treatments [8]. Therefore, understanding the factors that influence this decision-making process is crucial for optimizing patient outcomes, reducing costs, and enhancing the efficiency of dental practices.

While existing literature provides various recommendations for managing different types of defects in dental restorations, these recommendations are often not standardized or universally accepted. For instance, superficial discoloration, which often occurs in composite restorations, can frequently be managed through conservative approaches such as polishing or partial repair rather than full replacement. Similarly, the management of open margins or secondary caries may involve either repair or replacement, depending on the extent of the defect and patient-specific factors like caries risk and oral hygiene. However, there is a notable lack of established guidelines that offer clear, evidence-based protocols for determining the most appropriate method, particularly concerning the timing and necessity of repairing or replacing such restorations [9]. As a result, clinicians frequently have to rely on their judgment and experience when making these critical decisions. By expanding on these recommendations and understanding the nuances of each clinical scenario, clinicians can make more informed decisions that align with the best practices currently suggested in the literature, even in the absence of universally accepted guidelines.

The decision-making process in dental practice is inherently subjective, influenced by a range of tooth- and patient-specific factors [10], as well as the expertise and training of the dentists [11], the characteristics of the health-care system in a given country [12], and the availability of materials. Given the substantial impact of these factors on clinical practices globally, understanding the variations and potential biases in decision-making across different regions is crucial. The absence of standardized guidelines and the variability in clinical practices across different regions underscore the necessity of conducting a multinational study [13]. By examining decision-making processes in diverse clinical settings, this study aims to identify patterns and discrepancies in restorative practices worldwide. The multinational nature of the study allows for the comparison of clinical approaches across various health-care systems, providing a comprehensive understanding of how different factors—such as cultural, educational, and systemic influences—affect decision-making in restorative dentistry. This approach not only addresses the gaps in the literature but also helps in developing more universally applicable guidelines, informed by a wide range of clinical experiences and practices. Consequently, the selected methodology, which includes a broad-based survey across 21 countries, is designed to capture these variations and provide a robust dataset for analyzing global trends in the management of defective dental restorations.

2 | Materials and Methods

2.1 | Study Protocol

The questionnaire study, formulated by the lead investigator (Ö.H), was conducted during a 5-month period spanning from June to October 2023. Before distribution, the sample size for each country was determined independently, using the Raosoft sample size calculator (http://www.raosoft.com/sampl

esize.html). Irrespective of population size, a sample size of 165 participants per country would be sufficient to achieve an 80% confidence level. The selection of participating countries followed a nonspecific process, involving the contact of researchers specializing in endodontics, pediatric dentistry, prosthodontics, or restorative dentistry across the globe through professional networking platforms such as ResearchGate, Academia.edu, and email. Invitations were extended to researchers from 62 countries, resulting in 29 affirmative responses from 29 countries, covering 6 continents (Africa, Asia, Australia, Europe, North America, and South America). Unfortunately, researchers from eight countries (United States, South Korea, South Africa, The Netherlands, England, Canada, Brazil, and Australia) were unable to complete the process. Consequently, the study encompassed 21 countries, with representation from 4 continents. This included 2 countries from Africa (Egypt, Libya), 11 from Asia (Bangladesh, India, Indonesia, Jordan, Kazakhstan, Malaysia, Pakistan, Palestine, Saudi Arabia, Singapore, and Yemen), 6 from Europe (Croatia, Greece, Poland, Portugal, Spain, and Turkey), and 2 from South America (Colombia, Ecuador).

Due to the multinational nature of the research, the required ethical authorizations were obtained. Each investigator was in charge for complying with the ethical protocols of their respective country and attain individual ethical clearances, when necessary. The protocol of the study was approved by the ethical review board of the Nigde Omer Halisdemir University under reference number 2023/48.

The final iteration of the questionnaire was formulated in the English language. In June 2023, an online survey consisting of 14 questions (Supporting Information S1) was developed and accessed through a unique URL. The survey's objective was to gather data from general dentists and specialists in the fields of endodontics, pediatric dentistry, prosthodontics, and restorative dentistry, including those currently enrolled in specialty programs. Exclusions were made for other specialists such as maxillofacial surgeons, oral and maxillofacial radiologists, orthodontists, and periodontists, as these professionals typically do not perform these specific procedures. This selective approach was implemented to ensure that the survey results accurately represent the viewpoints and experiences of dentists involved in dental restorations. The survey link was disseminated across various social platforms, including country-specific dental associations, corporate and professional websites, email contacts, and a range of social media channels. To bolster response rates, reminder emails were dispatched at least twice, with a 2-week interval between communications.

To assess questionnaire's reliability, a test–retest method preceded its distribution. A cohort of 10 participants of each country completed the questionnaire twice at a 14-day interval. Kappa statistics was used to measure intra-rater agreement, revealing substantial agreement ($0.6 < \kappa < 0.80$) in 10 countries and almost perfect agreement ($0.80 < \kappa$) in 11 countries. The overall Kappa score of 0.78 shows substantial agreement (Table S2).

To ensure the validity and reliability of the questionnaire, we implemented a comprehensive validation process involving several critical steps. Initially, the questionnaire underwent an expert review by professionals in endodontics. These experts provided valuable feedback on the content, clarity, and relevance of the questions. Following the expert review, a pilot study was conducted with a small group of participants from various countries. This pilot testing allowed us to identify any potential issues, such as ambiguous wording or culturally specific references that might not be universally understood. Based on the feedback from this pilot study, we made minor revisions to the questionnaire, improving its clarity and ensuring that the questions would be interpreted consistently across different cultural contexts. To further validate the questionnaire, we employed a test–retest reliability method. Participants from each participating country completed the questionnaire twice, with a 14-day interval between administrations. The consistency of their responses was analyzed using Kappa statistics, which revealed substantial agreement across the board (overall Kappa score: 0.78), indicating that the questionnaire produced reliable and consistent results over time.

The survey consisted of two sections. The first contained five questions about demographic information, (country, age, gender, experience, and type of specialization). The second presented participants with the following initial clinical scenario: male subject, 30 years old, with no underlying health issues, he maintains good oral hygiene and is at low risk of developing caries. The subject presented to the clinic with a complaint about a defect in the occlusal restoration (Class 1) of his first lower molar which had been made 5 years ago. Clinically, the subject presented no signs or symptoms and the radiographic evaluation showed normal periapical tissues. Based on the initial scenario, eight distinct dental scenarios were given: partial loss or fracture of the restoration (Scenario 1), loss of dental hard tissue adjacent to the restoration (Scenario 2), secondary caries (Scenario 3), marginal discoloration (Scenario 4), open margin (Scenario 5), superficial discoloration (for composite) or corrosion (for amalgam) (Scenario 6), non-stable (mobile) restoration (Scenario 7), and disruption of occlusal integrity (Scenario 8) (Figure 1). Participants were requested to identify the preferred treatment option (repair, replacement, or no intervention) for each of the aforementioned scenarios. In addition, participants were asked which factors might alter their choice from repair toward replacement.

A subgroup analysis was stratified by the Human Development Index and the coverage of minimal invasive treatment costs by health-care systems. The countries involved in the study were categorized according to their HDI scores into four groups: very high human development (Singapore, Spain, Greece, Poland, Portugal, Croatia, Saudi Arabia, Turkey, Kazakhstan, and Malaysia), high human development (Colombia, Ecuador, Egypt, Jordan, Libya, Palestine, and Indonesia), medium human development (Bangladesh, India), and low human development (Pakistan, Yemen). Additionally, countries were further categorized based on whether their health-care systems cover the costs of minimal invasive treatments. Countries where the health-care systems cover these costs include Colombia, Croatia, Ecuador, Egypt, Indonesia, Jordan, Pakistan, and Turkey. On the other hand, countries where the health-care systems do not cover these costs include Bangladesh, Greece, India, Kazakhstan, Libya, Malaysia, Palestine, Poland, Portugal, Saudi Arabia, Singapore, Spain, and Yemen.

In order to mitigate the potential for participation bias, respondents were encouraged to include their email address. This

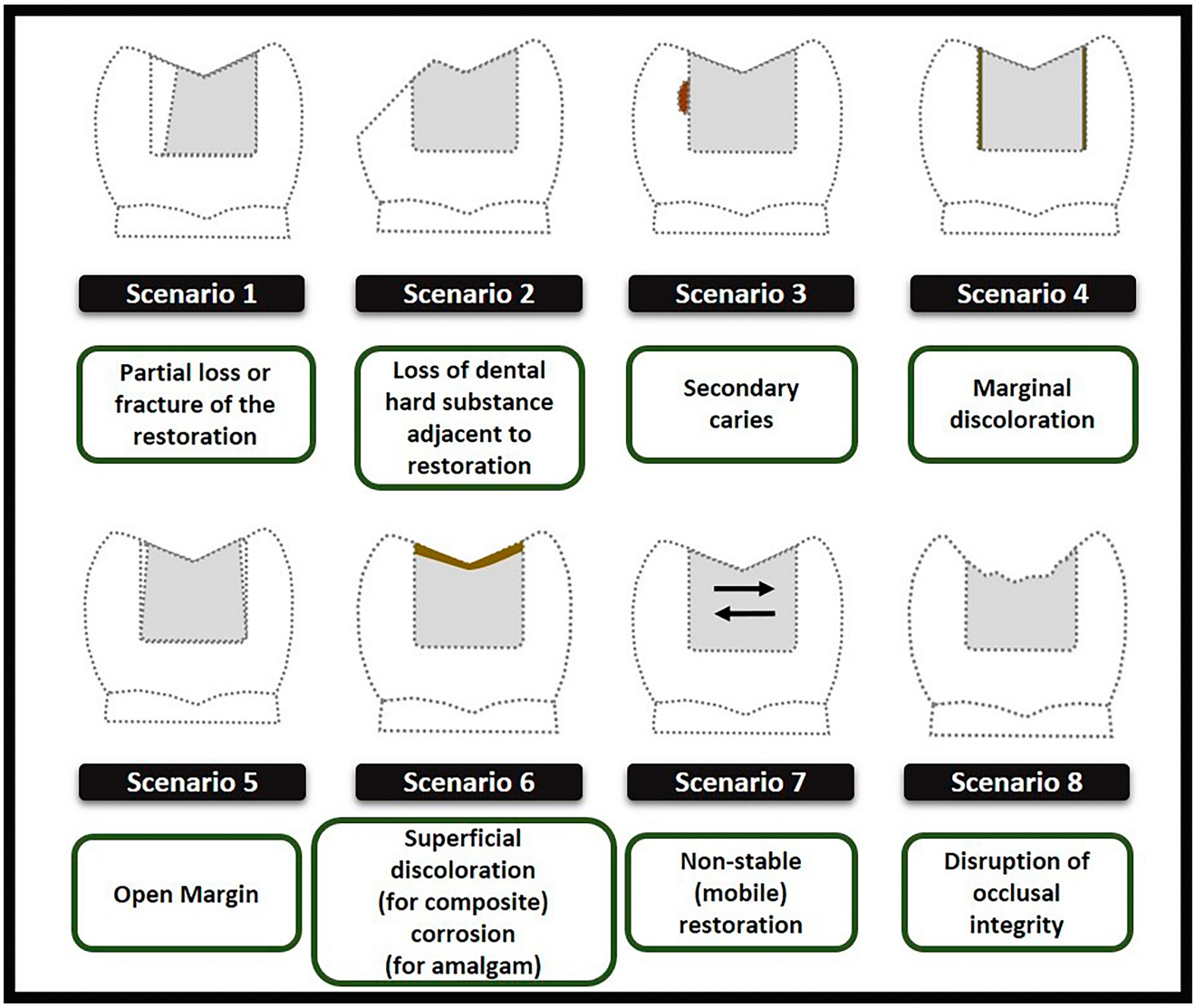

FIGURE 1 | A schematic illustration depicting eight distinct restoration defect scenarios.

allowed us to cross-reference and identify instances of multiple responses from the same individual and subsequently merge them into a single, consolidated response.

2.2 | Statistical Analysis

The statistical analysis was conducted using Jamovi (Version 2.3.26) software. Meta-analysis was employed to determine the pooled odds ratio of repair versus replacement. Forest plots were generated using the RevMan 5.3 program (The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark). Statistical heterogeneity between studies was assessed using the Higgins I2 test, categorizing heterogeneity as not significant (0%–30%), moderate (30%–50%), significant (50%–75%), or very significant (> 75%). Owing to the observed statistical heterogeneity, a meta-analysis model utilizing a random effects model with 95% confidence intervals (CI) was adopted. The effect size was measured using the risk ratio (RR). All analyses were conducted at a significance level of $\alpha = 0.05$.

3 | Results

The present study reports on the results of a survey completed by 3680 dental practitioners from 21 countries. Respondent's mean age was 34.3 ± 10.1 years (range: 20–77), 60.1% of whom were female. The highest participation rate was recorded in Croatia (208 respondents), and the lowest in Singapore and Egypt (165 respondents each). Individuals with 2–5 years of experience (22.7%) accounted for the highest participation rate, while those with over 30 years of experience had the lowest (5.5%). General dentists accounted for the majority of respondents (58%). A comprehensive description of the demographics of the respondents is presented in Table 1.

For composite restorations, most of the respondents significantly preferred repair over replacement in the following scenarios: partial loss or fracture of the restoration (RR: 0.72; 95% CI: 0.58, 0.89; $p = 0.002$), superficial discoloration (RR: 0.28; 95% CI: 0.20, 0.38; $p < 0.001$), loss of dental hard substance adjacent to the restoration (RR: 0.75; 95% CI: 0.62, 0.91; $p = 0.004$), and disruption of occlusal integrity (RR: 0.37; 95% CI: 0.29, 0.48;

TABLE 1 | The frequency of demographic attributes involved in the study.

	Overall ($N=3680$)
Country	
Bangladesh	170 (4.6%)
Colombia	167 (4.5%)
Croatia	208 (5.7%)
Ecuador	182 (4.9%)
Egypt	165 (4.5%)
Greece	175 (4.8%)
India	183 (5.0%)
Indonesia	176 (4.8%)
Jordan	190 (5.2%)
Kazakhstan	171 (4.6%)
Libya	174 (4.7%)
Malaysia	172 (4.7%)
Pakistan	178 (4.8%)
Palestine	169 (4.6%)
Poland	167 (4.5%)
Portugal	183 (5.0%)
Saudi Arabia	171 (4.6%)
Singapore	165 (4.5%)
Spain	168 (4.6%)
Turkey	174 (4.7%)
Yemen	172 (4.7%)
Gender	
Male	1467 (39.9%)
Female	2213 (60.1%)
Age	
Mean (SD)	34.3 (10.1)
Range	20.0–77.0
Experience	
≤2 years	834 (22.7%)
2≤5 years	836 (22.7%)
5≤10 years	670 (18.2%)
10≤20 years	770 (20.9%)
20≤30 years	367 (10.0%)
>30 years	203 (5.5%)
Specialization	
General dentist	2135 (58.0%)
Specialization in endodontics	727 (19.8%)
Specialization in pediatric dentistry	206 (4.6%)
Specialization in prosthodontic	274 (7.4%)
Specialization in restorative dentistry	338 (9.2%)

(Continues)

TABLE 1 | (Continued)

$p<0.001$). However, replacement was significantly preferred over repair in cases of marginal discoloration (RR: 1.97; 95% CI: 1.55, 2.49; $p<0.001$), open margin (RR: 3.93; 95% CI: 2.68, 5.76; $p<0.001$), non-stable/loose restoration (RR: 12.17; 95% CI: 8.17, 18.11; $p<0.001$), and secondary caries (RR: 2.43; 95% CI: 1.87, 3.16; $p<0.001$) (Figure 2, Table 2). Subgroup analysis did not reveal significant differences between continents across all scenarios ($p>0.05$), except for secondary caries ($p<0.001$). In this case, African countries (RR: 4.62; 95% CI: 3.64, 5.86; $p<0.001$) showed a greater tendency toward replacement when compared to Asian (RR: 2.13; 95% CI: 1.40, 3.24; $p<0.001$) and South American (RR: 1.33; 95% CI: 1.03, 1.71; $p=0.03$) countries. Significant heterogeneity across countries was observed in all scenarios ($I^2>92\%$) (Table 2).

For amalgam restorations, the majority of respondents significantly favored replacement over repair in all scenarios: partial loss or fracture of the restoration (RR: 3.94; 95% CI: 2.93, 5.31; $p<0.001$), corrosion (RR: 1.59; 95% CI: 1.24, 2.03; $p<0.001$), loss of dental hard substance adjacent to the restoration (RR: 4.70; 95% CI: 3.59, 6.16; $p<0.001$), disruption of occlusal integrity (RR: 1.70; 95% CI: 1.37, 2.10; $p<0.001$), marginal discoloration (RR: 6.04; 95% CI: 4.51, 8.08; $p<0.001$), open margin (RR: 5.14; 95% CI: 4.02, 6.57; $p<0.001$), non-stable/loose restoration (RR: 24.22; 95% CI: 13.05, 44.95; $p<0.001$), and secondary caries (RR: 6.94; 95% CI: 5.53, 8.71; $p<0.001$) (Figure 3, Table 3). Subgroup analysis did not reveal significant differences between continents across all scenarios ($p>0.05$), except for partial loss or fracture of the restoration ($p=0.04$). Specifically, South American countries (RR: 6.20; 95% CI: 4.66, 8.25; $p<0.001$) demonstrated a greater tendency toward replacement compared to European countries (RR: 2.61; 95% CI: 1.54, 4.42; $p<0.001$). Significant heterogeneity across countries was observed in all scenarios ($I^2>84\%$) (Table 3).

Subgroup analyses for amalgam restorations revealed that respondents significantly favored repair over replacement in countries with very high HDI scores for the scenario of partial loss or fracture of the restoration (RR: 2.99; 95% CI: 1.91, 4.67; $p=0.01$). Similarly, in countries with low HDI scores, respondents also significantly favored repair over replacement for the same scenario (RR: 3.58; 95% CI: 2.74, 4.69; $p=0.01$). Additionally, the study found no significant impact of health-care systems covering the cost of minimal invasive treatment on restorative treatment outcomes, as no statistical significance was observed in any of the related scenarios (Table 4).

The "high risk of dental caries" (73.34%), the "loss of more than half of the total restoration" (62.04%), and "poor oral hygiene" (59.24%) emerged as the three primary factors influencing

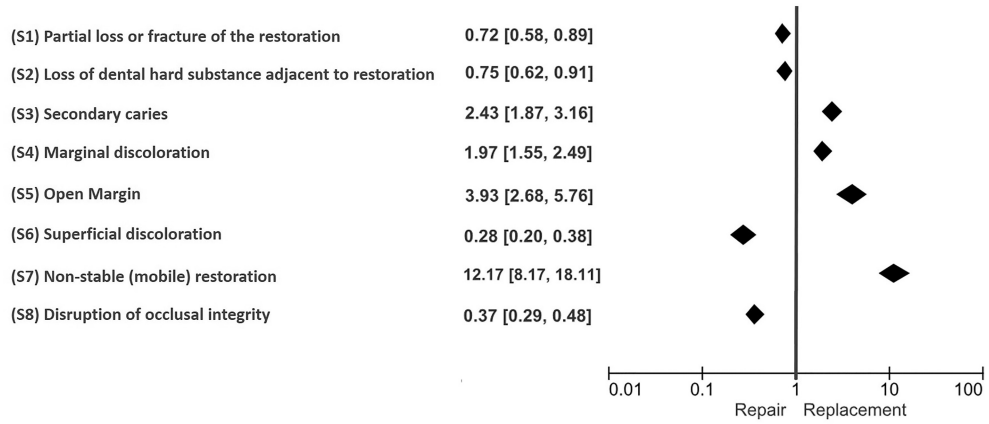

FIGURE 2 | A forest plot depicting the risk ratio of repair versus replacement in eight distinct dental composite defect scenarios.

decision-making, leading to a shift from repair to replacement. The "inability to use rubber dam" had the least influence (14.48%) on respondents' decision-making. A minority of respondents (4.81%) indicated that "nothing" could alter their decision from repair to replacement (Figure 4).

4 | Discussion

The decision-making process regarding whether to repair or replace defective restorations is complex, with numerous factors that significantly influence clinical practices across the globe [12, 14–16]. The present study aimed to assess clinical factors, revealing significant disparities in approaches among dentists worldwide. Material type in the original restoration strongly influenced repair versus replacement choices and, while the decision to repair composite restorations was found to be case-dependent, replacement of amalgam restorations was significantly favored across all scenarios and countries. The main factors influencing decision-making were caries risk, restoration size, and patient oral hygiene.

With regard to resin composite repair and replacement, two different behaviors were observed. On one hand, in scenarios of "partial loss or fracture of the restoration," "loss of dental hard tissue adjacent to the restoration," "superficial discolouration," and "disruption of occlusal integrity" the majority of respondents favored repair over replacement, is in line with established recommendations for addressing defective composite restorations, emphasizing repair for localized and accessible defects or merely refurbish the restoration if the issues are superficial [17]. Resin composite restorations are known to undergo degradation over time, stemming from mechanical and physical factors like wear and abrasion or chemical degradation mechanisms such as enzymatic, hydrolytic, acidic, or temperature-related breakdown [18–21]. However, compared to traditional materials like amalgam, resin composites offer the distinct advantage of enabling additive restorative techniques and consequently allow for minimal invasive procedures, including repair. The primary advantage of this approach is its potential to decrease iatrogenic damage (halting the rapid acceleration of the "restoration cycle"), be more cost-effective, improve the quality and longevity of the restoration, decrease chair time, and be less traumatic for patients (in some cases the use of local anesthesia can be avoided) [22–24].

On the other hand, replacement was significantly preferred over repair in cases of non-stable/loose restoration, open/defective margins, secondary caries, and marginal discoloration. Secondary caries has been reported as the main reason for restoration replacement [5, 25, 26]. This aligns with our research, indicating a preference for replacement when secondary caries or marginal discoloration is present. The term "secondary caries" lacks a consistent definition and its diagnosis varies among dental practitioners, often lacking objective criteria [27]. It is important to note that new caries should be clinically treated in the same manner as initial caries in a healthy tooth [28]. With regard marginal discoloration, it can arise due to inadequate acid etching of the enamel prior to composite resin restoration placement, flawed restoration fabrication, or the entrapment of air bubbles on the restoration surface and does not necessarily indicate the presence of caries.

In our research, the preference for replacement over repair is attributed to the detection of "restorations with defective margins." The lack of standardized criteria for assessing restoration failure may prompt dentists to choose surgical intervention when they are uncertain about meeting a diagnostic threshold. This cautious approach, known as "defensive dentistry," often leads to the selection of replacement over a range of minimally invasive options, which currently lack evidence-based support [17]. Nevertheless, contemporary evidence challenges this trend for two main reasons: (1) Secondary caries reflects a primary lesion in biofilm composition without significantly compromising the affected area [25]; (2) both repaired and replaced restorations demonstrate similar survival rates concerning marginal defects and secondary caries, especially in patients with low to medium caries risk [29–32]. Considering the numerous benefits associated with restoration repair [22], this treatment modality should be recommended more frequently, particularly for patients with low to medium caries risk who experience failures due to secondary caries or marginal defects (e.g., defective margins or marginal discoloration) [33]. Notably, except for secondary caries, no significant global variations were observed across all scenarios. However, African countries exhibited a higher inclination toward replacement in cases of secondary caries. This tendency

TABLE 2 | Pooled estimates of the risk ratio (RR) obtained from the comparison of repair (reference) with replacement in the scenarios regarding resin based composite restorations.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
Africa								
Egypt	0.83 [0.67, 1.04]	1.09 [0.87, 1.37]	4.19 [3.02, 5.82]	2.78 [2.05, 3.79]	4.86 [3.05, 7.74]	0.39 [0.28, 0.55]	6.86 [4.58, 10.27]	0.47 [0.36, 0.61]
Libya	0.89 [0.72, 1.10]	0.80 [0.64, 0.99]	5.14 [3.64, 7.27]	2.97 [2.19, 4.04]	11.98 [7.24, 19.83]	0.23 [0.16, 0.34]	18.33 [9.69, 34.67]	0.39 [0.30, 0.51]
Subtotal [95% CI]	0.86 [0.74, 1.00]	0.93 [0.68, 1.27]	4.62 [3.64, 5.86]	2.88 [2.31, 3.58]	7.59 [3.13, 18.38]	0.31 [0.18, 0.51]	10.88 [4.01, 29.56]	0.43 [0.36, 0.52]
Heterogeneity	$I^2 = 0\%$	$I^2 = 74\%$	$I^2 = 0\%$	$I^2 = 0\%$	$I^2 = 85\%$	$I^2 = 76\%$	$I^2 = 86\%$	$I^2 = 0\%$
Test for overall effect	$p = 0.06$	$p = 0.66$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
Asia								
Bangladesh	0.15 [0.10, 0.22]	0.18 [0.10, 0.32]	0.18 [0.13, 0.26]	1.33 [0.75, 2.36]	1.21 [0.79, 1.85]	0.27 [0.16, 0.44]	7.00 [4.67, 10.49]	0.16 [0.10, 0.27]
India	0.57 [0.46, 0.72]	0.85 [0.68, 1.06]	2.65 [2.05, 3.43]	2.77 [2.09, 3.67]	3.00 [1.96, 4.59]	0.39 [0.29, 0.53]	7.14 [4.80, 10.61]	0.56 [0.45, 0.71]
Indonesia	0.90 [0.73, 1.11]	0.69 [0.55, 0.87]	1.92 [1.52, 2.42]	3.03 [2.25, 4.07]	3.30 [2.13, 5.10]	0.30 [0.22, 0.40]	9.94 [6.21, 15.89]	0.29 [0.22, 0.40]
Jordan	0.62 [0.50, 0.76]	0.88 [0.71, 1.10]	2.92 [2.25, 3.78]	4.38 [2.95, 6.50]	6.51 [4.17, 10.19]	0.15 [0.09, 0.25]	61.67 [20.06, 189.54]	0.27 [0.20, 0.37]
Kazakhstan	2.91 [2.21, 3.82]	2.32 [1.80, 2.99]	3.20 [2.41, 4.25]	3.15 [2.37, 4.19]	9.45 [5.77, 15.47]	1.18 [0.95, 1.48]	3.31 [2.48, 4.41]	1.72 [1.26, 2.35]
Malaysia	1.73 [1.38, 2.17]	0.56 [0.44, 0.71]	2.07 [1.63, 2.63]	1.25 [0.98, 1.59]	1.71 [1.12, 2.62]	0.88 [0.69, 1.13]	2.58 [2.00, 3.34]	0.58 [0.46, 0.74]
Pakistan	0.70 [0.56, 0.86]	1.45 [1.16, 1.81]	2.07 [1.64, 2.62]	0.64 [0.51, 0.80]	0.44 [0.29, 0.67]	0.13 [0.08, 0.21]	10.06 [6.29, 16.10]	0.25 [0.18, 0.34]
Palestine	0.92 [0.74, 1.14]	0.73 [0.58, 0.92]	3.42 [2.56, 4.58]	3.29 [2.34, 4.63]	9.75 [5.93, 16.04]	0.25 [0.17, 0.37]	9.50 [5.94, 15.18]	0.42 [0.32, 0.55]
Saudi Arabia	0.51 [0.41, 0.65]	0.46 [0.36, 0.60]	1.33 [1.07, 1.65]	2.04 [1.53, 2.72]	13.12 [7.84, 21.95]	0.12 [0.07, 0.21]	11.21 [6.78, 18.56]	0.14 [0.09, 0.22]
Singapore	0.98 [0.79, 1.21]	1.12 [0.82, 1.51]	8.65 [5.50, 13.61]	2.44 [1.65, 3.62]	6.55 [4.05, 10.59]	0.20 [0.08, 0.51]	331.00 [20.79, 5269.87]	0.70 [0.43, 1.13]
Yemen	0.81 [0.65, 1.00]	0.87 [0.69, 1.10]	2.95 [2.25, 3.88]	2.15 [1.63, 2.84]	4.18 [2.67, 6.56]	0.35 [0.26, 0.48]	7.45 [4.91, 11.30]	0.29 [0.22, 0.40]
Subtotal [95% CI]	0.78 [0.56, 1.10]	0.80 [0.59, 1.07]	2.13 [1.40, 3.24]	2.14 [1.47, 3.10]	3.71 [2.01, 6.82]	0.30 [0.18, 0.50]	8.67 [5.32, 14.13]	0.38 [0.26, 0.56]
Heterogeneity	$I^2 = 96\%$	$I^2 = 93\%$	$I^2 = 96\%$	$I^2 = 94\%$	$I^2 = 95\%$	$I^2 = 95\%$	$I^2 = 92\%$	$I^2 = 94\%$
Test for overall effect	$p = 0.16$	$p = 0.13$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
Europe								
Croatia	0.86 [0.71, 1.04]	0.82 [0.68, 1.01]	3.93 [2.97, 5.19]	1.54 [1.24, 1.93]	3.56 [2.37, 5.35]	0.34 [0.25, 0.46]	207.00 [29.30, 1462.63]	0.21 [0.16, 0.29]
Greece	1.27 [1.03, 1.57]	1.11 [0.90, 1.37]	4.47 [3.24, 6.16]	2.55 [1.85, 3.51]	13.31 [7.96, 22.27]	0.13 [0.07, 0.22]	86.50 [21.80, 343.16]	0.36 [0.27, 0.48]

(Continues)

TABLE 2 | (Continued)

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
Poland	0.52 [0.41, 0.67]	0.25 [0.18, 0.36]	3.07 [2.32, 4.06]	0.83 [0.61, 1.12]	3.93 [2.48, 6.21]	0.21 [0.13, 0.35]	40.75 [15.47, 107.33]	0.34 [0.25, 0.46]
Portugal	0.25 [0.18, 0.34]	0.33 [0.25, 0.43]	3.36 [2.54, 4.43]	0.96 [0.76, 1.21]	1.04 [0.69, 1.58]	0.15 [0.10, 0.25]	29.50 [13.42, 64.83]	0.33 [0.23, 0.46]
Spain	0.66 [0.53, 0.83]	0.74 [0.60, 0.93]	2.09 [1.64, 2.67]	1.88 [1.41, 2.49]	3.00 [1.92, 4.71]	0.30 [0.21, 0.44]	6.00 [4.12, 8.73]	0.38 [0.28, 0.51]
Turkey	0.41 [0.32, 0.53]	0.68 [0.54, 0.85]	2.33 [1.82, 2.98]	3.77 [2.65, 5.37]	7.84 [4.84, 12.69]	0.12 [0.07, 0.21]	23.86 [11.54, 49.33]	0.32 [0.24, 0.43]
Subtotal [95% CI]	0.59 [0.38, 0.90]	0.59 [0.39, 0.88]	3.07 [2.41, 3.89]	1.66 [1.09, 2.54]	4.04 [2.03, 8.06]	0.20 [0.14, 0.29]	33.41 [10.33, 108.04]	0.32 [0.27, 0.37]
Heterogeneity	$I^2 = 95\%$	$I^2 = 94\%$	$I^2 = 78\%$	$I^2 = 93\%$	$I^2 = 93\%$	$I^2 = 77\%$	$I^2 = 92\%$	$I^2 = 41\%$
Test for overall effect	$p = 0.02$	$p = 0.01$	$p < 0.001$	$p = 0.02$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
South America								
Colombia	0.69 [0.55, 0.86]	1.19 [0.95, 1.49]	1.17 [0.94, 1.45]	1.00 [0.75, 1.33]	2.02 [1.30, 3.12]	0.25 [0.16, 0.40]	15.70 [8.60, 28.67]	0.21 [0.14, 0.31]
Ecuador	0.71 [0.57, 0.88]	0.70 [0.56, 0.86]	1.51 [1.22, 1.88]	2.05 [1.61, 2.62]	3.32 [2.16, 5.10]	0.73 [0.58, 0.92]	4.45 [3.25, 6.11]	0.98 [0.79, 1.21]
Subtotal [95% CI]	0.70 [0.60, 0.81]	0.91 [0.54, 1.54]	1.33 [1.03, 1.71]	1.44 [0.71, 2.91]	2.59 [1.59, 4.22]	0.44 [0.15, 1.29]	8.17 [2.20, 30.35]	0.46 [0.09, 2.23]
Heterogeneity	$I^2 = 0\%$	$I^2 = 91\%$	$I^2 = 64\%$	$I^2 = 93\%$	$I^2 = 61\%$	$I^2 = 94\%$	$I^2 = 93\%$	$I^2 = 98\%$
Test for overall effect	$p < 0.001$	$p = 0.73$	$p = 0.03$	$p = 0.31$	$p < 0.001$	$p = 0.13$	$p = 0.02$	$p < 0.001$
Total [95% CI]	0.72 [0.58, 0.89]	0.75 [0.62, 0.91]	2.43 [1.87, 3.16]	1.97 [1.55, 2.49]	3.93 [2.68, 5.76]	0.28 [0.20, 0.38]	12.17 [8.17, 18.11]	0.37 [0.29, 0.48]
Heterogeneity	$I^2 = 94\%$	$I^2 = 93\%$	$I^2 = 95\%$	$I^2 = 93\%$	$I^2 = 93\%$	$I^2 = 94\%$	$I^2 = 93\%$	$I^2 = 93\%$
Test for overall effect	$p = 0.002$	$p = 0.004$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
Test for subgroup differences	$p = 0.15$	$p = 0.33$	$p < 0.001$	$p = 0.06$	$p = 0.20$	$p = 0.33$	$p = 0.22$	$p = 0.11$

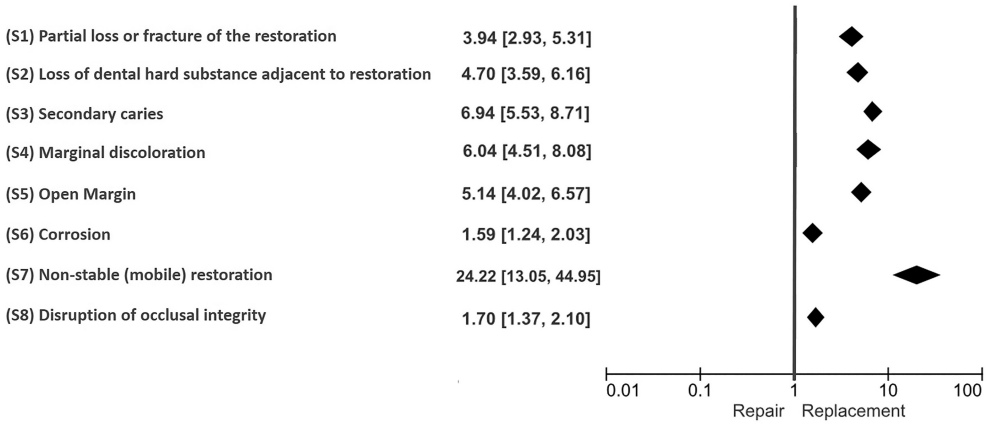

FIGURE 3 | A forest plot depicting the risk ratio of repair versus replacement in eight distinct amalgam defect scenarios.

may be linked to the relatively high prevalence of caries in the population, which contraindicates the option of repair.

For amalgam restorations, in all scenarios examined, the majority of respondents across all countries significantly favored replacement over repair. This aligns with previous research indicating a low rate of repair [13, 34–36] for such restorations. Despite evidence demonstrating the success of repair with new amalgam [37] or resin composite [38, 39], clinicians have historically shown reluctance to opt for repair over replacement. However, our findings contradict some studies showing that clinicians were less inclined to intervene in scenarios involving amalgam compared to composite restorations [40]. The preference for replacement in the current study probably stem from dentists perceiving repair of amalgam restorations as "patchwork dentistry" [41] or indicative of lower practice standards [10, 42], regardless of evidence suggesting a poor correlation between the presence of defective margins and caries after amalgam restoration removal [43]. Another clinical factor that may have an influence of replacement of amalgam restorations is the complexity of the bonding procedure. While repair is often seen as a "minor" procedure, many dentists hesitate to execute complex bonding procedures [44] for what is considered a "simple" restoration repair. This step is crucial because the successful repair of a defective restoration depends on the formation of a durable bond between the original restoration and the repair material [45], and failure to achieve this bond can reduce the survival of the repaired restoration. Additionally, aesthetic considerations and concerns about potential health risks associated with amalgam, coupled with attempts to restrict or ban its use, have too shown to influence decision-making processes [46].

While the detection of restoration defects and subsequent decision-making are often based primarily on visual and tactile evaluations, the management strategy for the restored tooth should be grounded in a thorough risk assessment [17] as success of restoration repair is significantly influenced by proper case selection, as well as the materials and techniques used [30, 35]. A range of patient-, tooth-, and clinical-level factors play an important role on the decision-making of repair versus replacement. In our study, patient-level factors such as a "high risk of caries" and "poor oral hygiene habits" emerged as the most influential in clinicians' decisions, often prompting replacement. These factors are commonly regarded as contraindications for repair, as outlined by Blum et al. [17]. The impact of these factors on restoration replacement is supported by previous studies where individual caries risk and parafunctional habits like bruxism have been identified as predominant reasons for decreased restoration longevity [47–49] and for determining whether to repair or replace a defective restoration [30, 32].

At the tooth level, factors such as the size and age of the restoration, as well as whether the restoration has been repaired multiple times, were identified in our study as significant factors shifting the decision from repair to replacement. These variables have been shown to exert a notable influence on restoration longevity [50–52], and are associated with increased rates of restoration replacement [53], consistent with our findings. Clinician-level factors showed less impact on the decision-making process: Only 30% of respondents would alter their decision from repair to replacement if the restoration had been performed by another dentist. This finding contradicts previous research indicating that changing dentists had a significant impact on restoration survival rates, with some studies reporting up to a 30% difference [53, 54].

Patient-related factors, such as caries risk and oral hygiene, significantly influence the decision-making process between repair and replacement. For patients with high caries risk or poor oral hygiene, the likelihood of restoration failure is increased, which often justifies opting for replacement over repair [49]. Conversely, for patients with good oral hygiene and low caries risk, repair should be considered to preserve tooth structure and reduce treatment costs [47–49]. Clinicians should assess these factors comprehensively during the treatment planning process, utilizing tools like caries risk assessment models and personalized oral hygiene strategies to inform their decisions. Additionally, the analysis of variables such as caries risk and oral hygiene could be expanded to provide more detailed insights. For example, future research could explore how different levels of caries risk affect the long-term success of repair versus replacement. Additionally, the role of patient compliance with oral hygiene practices in the longevity of repairs should be investigated, as this could further inform clinical decision-making.

TABLE 3 | Pooled estimates of the risk ratio (RR) obtained from the comparison of repair (reference) with replacement in the scenarios regarding dental amalgam.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
Africa								
Egypt	5.48 [3.79, 7.91]	6.84 [4.45, 10.52]	10.36 [6.25, 17.15]	5.22 [3.31, 8.24]	5.83 [3.96, 8.57]	1.86 [1.32, 2.62]	9.00 [5.63, 14.39]	1.62 [1.25, 2.09]
Libya	4.40 [3.14, 6.16]	5.91 [4.01, 8.72]	12.83 [7.41, 22.21]	11.00 [5.96, 20.29]	7.25 [4.77, 11.01]	1.41 [1.04, 1.90]	27.17 [12.36, 59.69]	1.52 [1.19, 1.95]
Subtotal [95% CI]	4.86 [3.79, 6.23]	6.31 [4.73, 8.42]	11.43 [7.88, 16.56]	7.37 [3.51, 15.46]	6.44 [4.85, 8.56]	1.60 [1.22, 2.10]	14.98 [4.84, 46.32]	1.57 [1.31, 1.87]
Heterogeneity	$I^2 = 0\%$	$I^2 = 0\%$	$I^2 = 0\%$	$I^2 = 74\%$	$I^2 = 0\%$	$I^2 = 31\%$	$I^2 = 84\%$	$I^2 = 0\%$
Test for overall effect	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$
Asia								
Bangladesh	6.00 [4.12, 8.74]	0.94 [0.60, 1.46]	4.09 [2.98, 5.61]	4.43 [2.01, 9.78]	2.17 [1.70, 2.78]	0.74 [0.50, 1.12]	15.40 [8.42, 28.15]	0.35 [0.23, 0.52]
India	8.78 [5.64, 13.66]	6.23 [4.17, 9.30]	8.26 [5.38, 12.70]	5.41 [3.60, 8.12]	5.72 [3.94, 8.30]	2.56 [1.88, 3.49]	11.43 [6.89, 18.96]	2.22 [1.71, 2.89]
Indonesia	6.95 [4.63, 10.44]	7.56 [4.84, 11.79]	7.79 [5.07, 11.97]	9.14 [5.49, 15.24]	6.90 [4.60, 10.37]	4.00 [2.84, 5.63]	40.50 [15.36, 106.81]	2.55 [1.91, 3.40]
Jordan	4.08 [3.03, 5.50]	6.55 [4.38, 9.78]	7.17 [4.87, 10.57]	11.44 [5.97, 21.94]	6.04 [4.20, 8.68]	1.22 [0.83, 1.79]	61.33 [19.95, 188.53]	1.49 [1.16, 1.92]
Kazakhstan	9.00 [5.62, 14.41]	8.69 [5.42, 13.93]	7.42 [4.83, 11.40]	6.90 [4.54, 10.48]	7.20 [4.75, 10.92]	10.21 [6.16, 16.95]	6.71 [4.47, 10.08]	4.41 [2.72, 7.14]
Malaysia	1.16 [0.94, 1.44]	2.06 [1.59, 2.66]	2.29 [1.79, 2.93]	1.47 [1.13, 1.90]	1.93 [1.52, 2.45]	1.40 [1.08, 1.83]	2.00 [1.58, 2.54]	1.08 [0.86, 1.36]
Pakistan	2.74 [2.11, 3.56]	9.06 [5.74, 14.29]	7.38 [4.92, 11.07]	3.34 [2.34, 4.79]	2.93 [2.23, 3.85]	1.21 [0.83, 1.75]	86.50 [21.80, 343.25]	1.92 [1.48, 2.50]
Palestine	3.88 [2.85, 5.30]	5.38 [3.68, 7.86]	7.53 [4.90, 11.55]	8.82 [4.91, 15.84]	8.59 [5.45, 13.53]	1.59 [1.12, 2.27]	15.40 [8.43, 28.15]	1.84 [1.40, 2.41]
Saudi Arabia	5.72 [3.96, 8.27]	5.05 [3.33, 7.66]	8.53 [5.41, 13.45]	6.25 [3.85, 10.13]	9.00 [5.72, 14.17]	0.74 [0.51, 1.07]	27.33 [12.45, 60.02]	0.74 [0.56, 0.99]
Singapore	3.29 [2.46, 4.40]	8.90 [4.80, 16.50]	13.91 [7.85, 24.66]	50.00 [6.99, 357.70]	10.45 [5.86, 18.67]	1.83 [0.69, 4.84]	331.00 [20.79, 5269.87]	2.42 [1.28, 4.57]
Yemen	4.29 [3.09, 5.96]	3.22 [2.30, 4.50]	5.30 [3.72, 7.54]	3.91 [2.61, 5.87]	5.22 [3.67, 7.44]	1.02 [0.75, 1.38]	8.94 [5.68, 14.09]	1.13 [0.89, 1.44]
Subtotal [95% CI]	4.38 [2.91, 6.61]	4.81 [3.14, 7.37]	6.51 [4.64, 9.13]	5.71 [3.51, 9.28]	5.16 [3.50, 7.61]	1.69 [1.12, 2.55]	18.59 [7.66, 45.10]	1.50 [1.08, 2.08]
Heterogeneity	$I^2 = 94\%$	$I^2 = 92\%$	$I^2 = 88\%$	$I^2 = 91\%$	$I^2 = 93\%$	$I^2 = 93\%$	$I^2 = 92\%$	$I^2 = 93\%$
Test for overall effect	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p = \mathbf{0.01}$	$p < \mathbf{0.001}$	$p = \mathbf{0.02}$
Europe								
Croatia	3.27 [2.52, 4.24]	4.29 [3.15, 5.82]	12.67 [7.77, 20.65]	6.84 [4.48, 10.46]	4.94 [3.61, 6.76]	1.68 [1.29, 2.19]	206.00 [29.16, 1455.53]	1.53 [1.23, 1.89]
Greece	6.52 [4.44, 9.58]	6.35 [4.32, 9.32]	14.73 [8.30, 26.12]	14.00 [6.45, 30.39]	8.28 [5.33, 12.85]	1.02 [0.76, 1.38]	173.00 [24.51, 1221.27]	1.53 [1.18, 1.99]
Poland	3.08 [2.30, 4.12]	5.09 [3.45, 7.51]	6.13 [4.18, 9.00]	6.44 [3.48, 11.92]	8.13 [5.03, 13.16]	3.08 [1.84, 5.17]	54.67 [17.81, 167.81]	8.77 [5.22, 14.73]

(Continues)

TABLE 3 | (Continued)

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
Portugal	1.01 [0.82, 1.24]	1.77 [1.41, 2.21]	5.21 [3.71, 7.31]	4.05 [2.73, 6.01]	2.02 [1.60, 2.55]	1.00 [0.72, 1.39]	60.00 [19.53, 184.34]	1.41 [1.08, 1.85]
Spain	3.16 [2.36, 4.22]	3.50 [2.57, 4.76]	4.41 [3.15, 6.18]	5.27 [3.28, 8.45]	4.31 [3.08, 6.04]	1.40 [1.00, 1.96]	10.57 [6.39, 17.48]	2.63 [1.90, 3.65]
Turkey	1.62 [1.30, 2.03]	2.50 [1.92, 3.25]	3.75 [2.78, 5.06]	12.25 [6.28, 23.90]	4.69 [3.35, 6.57]	0.70 [0.50, 0.98]	28.00 [12.75, 61.49]	1.21 [0.95, 1.54]
Subtotal [95% CI]	2.61 [1.54, 4.42]	3.53 [2.36, 5.30]	6.53 [4.35, 9.81]	6.88 [4.77, 9.92]	4.79 [2.98, 7.69]	1.28 [0.91, 1.81]	47.19 [16.50, 134.95]	2.03 [1.35, 3.04]
Heterogeneity	$I^2 = 96\%$	$I^2 = 91\%$	$I^2 = 85\%$	$I^2 = 65\%$	$I^2 = 91\%$	$I^2 = 85\%$	$I^2 = 84\%$	$I^2 = 93\%$
Test for overall effect	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p = 0.16$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$
South America								
Colombia	7.21 [4.69, 11.08]	11.50 [6.64, 19.92]	7.89 [5.08, 12.26]	3.68 [2.33, 5.83]	5.36 [3.71, 7.75]	1.31 [0.82, 2.08]	52.33 [17.04, 160.72]	1.18 [0.87, 1.61]
Ecuador	5.50 [3.75, 8.07]	5.20 [3.57, 7.57]	7.37 [4.78, 11.36]	5.90 [3.90, 8.94]	4.96 [3.47, 7.10]	3.38 [2.41, 4.73]	13.45 [7.56, 23.96]	3.83 [2.71, 5.41]
Subtotal [95% CI]	6.20 [4.66, 8.25]	7.54 [3.41, 16.67]	7.62 [5.59, 10.38]	4.71 [2.97, 7.49]	5.15 [3.98, 6.66]	2.13 [0.84, 5.39]	24.53 [6.02, 99.91]	2.12 [0.66, 6.82]
Heterogeneity	$I^2 = 0\%$	$I^2 = 82\%$	$I^2 = 0\%$	$I^2 = 55\%$	$I^2 = 0\%$	$I^2 = 91\%$	$I^2 = 80\%$	$I^2 = 96\%$
Test for overall effect	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p = 0.11$	$p < \mathbf{0.001}$	$p = 0.21$
Total [95% CI]	3.94 [2.93, 5.31]	4.70 [3.59, 6.16]	6.94 [5.53, 8.71]	6.04 [4.51, 8.08]	5.14 [4.02, 6.57]	1.59 [1.24, 2.03]	24.22 [13.05, 44.95]	1.70 [1.37, 2.10]
Heterogeneity	$I^2 = 95\%$	$I^2 = 91\%$	$I^2 = 85\%$	$I^2 = 87\%$	$I^2 = 90\%$	$I^2 = 90\%$	$I^2 = 95\%$	$I^2 = 91\%$
Test for overall effect	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$	$p < \mathbf{0.001}$
Test for subgroup differences	$p = \mathbf{0.04}$	$p = 0.10$	$p = 0.12$	$p = 0.59$	$p = 0.60$	$p = 0.62$	$p = 0.46$	$p = 0.63$

Note: A p-value of < 0.05 was considered significant.

TABLE 4 | Subgroup analyses of risk ratios according to the Human Development Index and health care systems' coverage of minimal invasive treatment costs.

	Human Development Index					Covering the cost of minimal invasive treatment by health-care systems		
	Very high	**High**	**Medium**	**Low**	***p***	**Covering**	**Not covering**	***p***
Composite resins								
Scenario 1	0.79 [0.53, 1.18]	0.79 [0.70, 0.88]	0.29 [0.07, 1.21]	0.75 [0.64, 0.87]	$p=0.56$	0.70 [0.60, 0.82]	0.73 [0.52, 1.03]	$p=0.82$
Scenario 2	0.70 [0.49, 1.00]	0.85 [0.72, 1.00]	0.40 [0.08, 2.03]	1.12 [0.68, 1.86]	$p=0.37$	0.90 [0.74, 1.10]	0.66 [0.49, 0.90]	$p=\mathbf{0.09}$
Scenario 3	2.98 [2.23, 3.98]	2.54 [1.69, 3.81]	0.70 [0.05, 10.26]	2.45 [1.73, 3.48]	$p=0.62$	2.28 [1.69, 3.08]	2.53 [1.70, 3.78]	$p=0.68$
Scenario 4	1.82 [1.34, 2.46]	2.55 [1.79, 3.62]	2.01 [0.98, 4.09]	1.17 [0.35, 3.87]	$p=0.41$	2.00 [1.25, 3.20]	1.95 [1.50, 2.54]	$p=0.92$
Scenario 5	4.75 [2.78, 8.11]	4.99 [3.14, 7.93]	1.90 [0.78, 4.64]	1.36 [0.15, 12.30]	$p=0.19$	3.09 [1.65, 5.79]	4.55 [2.78, 7.45]	$p=0.34$
Scenario 6	0.26 [0.14, 0.49]	0.30 [0.19, 0.46]	0.34 [0.24, 0.49]	0.22 [0.08, 0.59]	$p=0.79$	0.26 [0.16, 0.41]	0.29 [0.18, 0.45]	$p=0.76$
Scenario 7	19.06 [7.76, 46.80]	11.31 [6.70, 19.08]	7.07 [5.33, 9.38]	8.50 [6.23, 11.61]	$p=0.12$	14.46 [7.75, 26.98]	10.96 [6.53, 18.39]	$p=0.50$
Scenario 8	0.40 [0.27, 0.59]	0.39 [0.26, 0.58]	0.31 [0.08, 1.13]	0.27 [0.22, 0.34]	$p=0.23$	0.33 [0.22, 0.50]	0.40 [0.30, 0.55]	$p=0.44$
Amalgam								
Scenario 1	2.99 [1.91, 4.67]	5.06 [4.22, 6.06]	7.13 [4.90, 10.35]	3.39 [2.18, 5.27]	$p=\mathbf{0.01}$	4.09 [2.77, 6.04]	3.85 [2.51, 5.93]	$p=0.84$
Scenario 2	4.07 [2.85, 5.81]	6.46 [5.43, 7.68]	2.42 [0.37, 15.80]	5.34 [1.88, 15.19]	$p=0.11$	5.97 [4.09, 8.70]	4.05 [2.84, 5.78]	$p=0.14$
Scenario 3	6.56 [4.37, 9.86]	8.20 [6.93, 9.70]	5.73 [2.83, 11.57]	6.16 [4.45, 8.52]	$p=0.32$	7.47 [5.63, 9.93]	6.64 [4.83, 9.11]	$p=0.58$
Scenario 4	6.48 [3.71, 11.31]	7.06 [5.14, 9.69]	5.19 [3.61, 7.45]	3.58 [2.74, 4.69]	$p=\mathbf{0.01}$	6.25 [4.50, 8.66]	5.93 [3.86, 9.13]	$p=0.85$
Scenario 5	5.19 [3.39, 7.94]	6.16 [5.32, 7.14]	3.49 [1.30, 9.36]	3.87 [2.18, 6.86]	$p=0.28$	4.98 [4.07, 6.09]	5.26 [3.58, 7.71]	$p=0.80$
Scenario 6	1.54 [1.03, 2.32]	1.91 [1.34, 2.73]	1.39 [0.41, 4.68]	1.09 [0.86, 1.38]	$p=0.06$	1.66 [1.11, 2.49]	1.54 [1.12, 2.12]	$p=0.77$
Scenario 7	30.92 [8.85, 108.02]	22.43 [12.83, 39.24]	12.93 [8.77, 19.05]	25.94 [1.88, 358.26]	$p=0.29$	34.41 [16.26, 72.86]	18.78 [8.63, 40.89]	$p=0.27$
Scenario 8	1.87 [1.32, 2.64]	1.85 [1.43, 2.39]	0.88 [0.14, 5.56]	1.47 [0.87, 2.48]	$p=0.75$	1.76 [1.38, 2.24]	1.67 [1.20, 2.30]	$p=0.80$

Note: A p-value of <0.05 was considered significant.

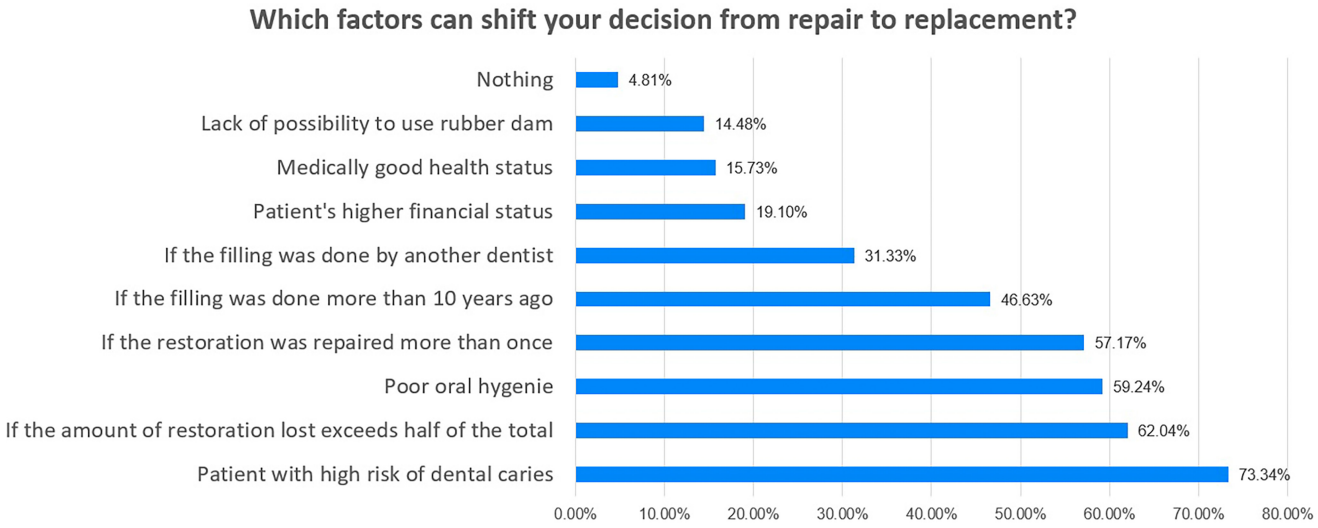

FIGURE 4 | Factors that influence the decision to shift from repairing to replacing defective dental restorations.

To effectively address the disparities observed in clinical decision-making across different regions, particularly those influenced by HDI, it is crucial to implement targeted, region-specific interventions. The significant differences identified in the subgroup analysis—where respondents in both very high and low HDI countries favored replacement over repair in specific scenarios—highlight the need for tailored educational programs. These programs should emphasize the benefits and techniques of repair over replacement, taking into account the unique economic, cultural, and health-care contexts of each region. Additionally, the establishment of international collaborative networks is essential. These networks could facilitate the exchange of best practices, clinical experiences, and resources among regions with varying HDI levels, thereby helping to reduce the observed disparities.

The validation process described above highlights the robustness of our questionnaire, making it a reliable tool for assessing clinical decision-making across different countries. The substantial agreement observed in the test–retest reliability analysis demonstrates that the questionnaire is capable of producing consistent and reliable data. Furthermore, the expert review and pilot testing stages ensured that the questionnaire was both comprehensive and culturally adaptable, allowing for its application in a wide range of settings. Researchers can confidently use this questionnaire to explore clinical practices in other contexts, comparing findings across different regions and health-care systems.

Despite robust scientific evidence advocating for repair rather than complete replacement, our study reveals significant disparities in treatment decisions for dental restorations with various types of defects. With responses from 3680 dental practitioners worldwide, this web-based survey provides a representative overview, allowing for generalization of the findings. However, some methodological limitations must be noted. The reliance on self-reported responses introduces bias, and the survey's sole use of English could affect response rates, particularly in countries where English is not the/a primary language. Moreover, the use of clinical scenarios oversimplifies complex clinical situations, potentially leading to misinterpretations or inadequate responses from participants. The large scale of the web-based survey limits the ability to ensure a suitable cohort selection and accurately calculate response rates. Despite attempts to reach dentists through country-specific dental associations, ensuring a fully representative cohort could not be guaranteed. To address potential heterogeneity between countries, we conducted a meta-analysis employing a random effects model, subgroup, and sensitivity analyses. This comprehensive approach permit a thorough examination of the data and identification of any existing heterogeneity. By using a random effects model, we accounted for variation in effect sizes between countries. Subgroup analyses further explored potential sources of heterogeneity, such as population characteristics based on continents. Overall, our methodological approach facilitated a comprehensive analysis that considered the intricacies of the data, resulting in accurate and reliable findings.

5 | Conclusion

This multinational study provides valuable insights into the factors influencing the complex decision-making process of repair versus replacement for defective restorations, revealing significant global disparities in clinical practices. Material type in the original restoration emerged as a key determinant, with composite restorations being considered for repair in case-specific situations, while replacement of amalgam restorations was consistently favored across all scenarios and countries. Patient- and tooth-level factors, such as high caries risk, poor oral hygiene, and restoration size, had the most significant impact on clinicians' decisions, often leading them to opt for replacement over repair. Given the disparities observed, there is an urgent need for the development of globally adaptable clinical guidelines that can be tailored to various cultural contexts and dental practices. Such guidelines would provide clinicians worldwide with evidence-based protocols to standardize care and improve patient outcomes.

Future research should focus on the external validation of these findings in diverse populations and clinical settings. Additionally, there is a need to create a more robust evidence base to inform clinical decision-making, particularly regarding the long-term outcomes of repair versus replacement in different patient demographics and health-care systems. These efforts will be crucial in overcoming the limitations and challenges identified in this study, ultimately leading to more consistent and effective global dental care practices.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.