**International Journal of Dental Sciences & Research**

# Longevity of Glass Ionomer vs. Composite Resin Restorations in High Caries-Risk African Populations

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**Abstract**

The selection of appropriate restorative materials for dental caries management in resource-limited settings remains a critical challenge in global oral health. This study examines the comparative longevity and clinical performance of glass ionomer cement (GIC) and composite resin restorations in high caries-risk populations across African countries, where factors such as limited access to dental care, high sugar consumption, inadequate oral hygiene practices, and challenging environmental conditions significantly influence treatment outcomes. Through a comprehensive analysis of existing clinical studies, systematic reviews, and longitudinal data from various African regions, this research evaluates survival rates, failure patterns, cost-effectiveness, and patient-centered outcomes associated with both restorative materials. The findings indicate that while composite resin restorations demonstrate superior aesthetic properties and mechanical strength under optimal conditions, glass ionomer cements exhibit remarkable clinical advantages in high caries-risk African populations due to their fluoride-releasing properties, moisture tolerance during placement, chemical adhesion to tooth structure, and reduced technique sensitivity. The evidence suggests that conventional and high-viscosity glass ionomer cements present a more pragmatic and sustainable solution for managing dental caries in resource-constrained African settings, particularly in primary teeth and atraumatic restorative treatment (ART) approaches. This research contributes to evidence-based decision-making for dental practitioners, public health officials, and policymakers working to improve oral health outcomes in vulnerable populations across the African continent.

**Keywords:** Glass ionomer cement, composite resin, dental restoration longevity, high caries-risk populations, African oral health, atraumatic restorative treatment, fluoride release, minimal intervention dentistry

## 1. Introduction

The global burden of dental caries disproportionately affects populations in low- and middle-income countries, with sub-Saharan Africa experiencing particularly elevated prevalence rates among both children and adults (Kasssebaum et al., 2015). The World Health Organization has consistently identified untreated dental caries as one of the most prevalent health conditions worldwide, affecting approximately 2.3 billion people with permanent teeth and 532 million children with primary teeth (World Health Organization, 2022). Within the African context, the epidemiological landscape of dental caries presents unique challenges that extend beyond mere disease prevalence to encompass complex interactions between socioeconomic factors, dietary transitions, limited healthcare infrastructure, and cultural practices that collectively influence oral health outcomes.

The contemporary epidemiological data reveals that in 2019, 28.5% of the population in the WHO African Region had untreated caries of permanent teeth, while 38.6% of children aged 1-9 years had untreated caries of deciduous teeth. Furthermore, systematic reviews have demonstrated that up to 36% of children aged 12 in Africa have dental caries, indicating a substantial disease burden that requires immediate attention from healthcare systems and policymakers. The severity of the problem is amplified by the fact that individuals who do not practice tooth brushing are nearly twice as likely to develop dental caries, highlighting the critical role of preventive behaviors in disease management.

The African healthcare infrastructure faces significant constraints that necessitate careful consideration of material selection for dental restorations. The continent carries 24% of the global disease burden but has only 3% of the world's health workforce, with many African countries having fewer than one dentist per 10,000 people. This scarcity of dental professionals, combined with limited access to advanced dental equipment and challenging working conditions in remote areas, creates an environment where treatment approaches must prioritize simplicity, reliability, and biological compatibility over purely aesthetic considerations.

The debate surrounding the optimal restorative material for high caries-risk populations centers on balancing clinical performance, cost-effectiveness, and practical feasibility. Glass ionomer cements, first introduced in the 1970s, have undergone substantial evolution, with high-viscosity formulations demonstrating enhanced mechanical properties while retaining the material's fundamental advantages of fluoride release, chemical adhesion to tooth structure, and reduced moisture sensitivity during placement (Frencken et al., 2012). Conversely, composite resin restorations offer superior aesthetic outcomes, exceptional mechanical strength, and versatility in application, making them the preferred choice in well-resourced clinical settings where optimal moisture control and multi-step bonding procedures can be reliably executed.

Recent clinical investigations comparing these materials have yielded nuanced findings that challenge simplistic categorizations of material superiority. In noncarious cervical lesions, glass ionomer cements demonstrated significantly better retention than composite resins, with this being the only parameter where one material showed clear superiority over another. Furthermore, high-viscosity glass ionomer cements and composite resins presented comparable clinical performance in posterior permanent teeth up to 36 months, with high-viscosity glass ionomer wear in Class I restorations at 24 months being the only poorer result compared to composite resin. These findings suggest that the performance gap between these materials has narrowed substantially, particularly for high-viscosity glass ionomer formulations that incorporate improved powder-to-liquid ratios and particle size distributions.

The implementation of atraumatic restorative treatment (ART) in African settings represents a paradigm shift in dental care delivery, particularly for populations with limited access to conventional dental facilities. The approach was born 25 years ago in Tanzania, where a pilot study treating 28 teeth with hand excavators and restorative cement resulted in only one tooth requiring extraction after 9 months, with all others functioning well despite visible surface wear. This foundational work demonstrated that minimally invasive approaches could be successfully implemented in resource-constrained environments where tooth extraction had previously been the only viable treatment option for painful dental conditions.

The clinical success rates of ART restorations have been extensively documented across various African populations and settings. Meta-analyses have shown cumulative survival rates for single-surface ART restorations in primary teeth over the first two years as 93%, while multiple-surface restorations achieved 62% survival, and single-surface ART restorations in permanent teeth demonstrated 85% survival at three years and 80% at five years. These survival rates are particularly impressive considering the challenging conditions under which many of these restorations are placed, including limited moisture control, absence of electrical equipment, and varying levels of operator expertise. Furthermore, a longitudinal study in Nigeria found that over 90% of subjects had never undergone dental treatment and 63% perceived dental treatment as painful, yet after undergoing ART treatment, 98% admitted that ART was not painful, highlighting the psychological benefits of this approach in populations with significant dental anxiety and limited prior dental experience.

## 2. Materials and Methods

### 2.1 Literature Search Strategy and Selection Criteria

This comprehensive review employed a systematic approach to identify, evaluate, and synthesize existing evidence on the comparative longevity of glass ionomer cement and composite resin restorations in high caries-risk African populations. The literature search was conducted across multiple electronic databases including PubMed, Scopus, Web of Science, and Google Scholar, covering publications from January 2000 through October 2024. The search strategy incorporated Medical Subject Headings (MeSH) terms and free-text keywords related to glass ionomer cement, composite resin, dental restoration longevity, survival rates, clinical performance, atraumatic restorative treatment, high caries-risk populations, and specific African countries and regions.

The inclusion criteria for this review encompassed randomized controlled trials, prospective and retrospective cohort studies, and comparative clinical trials that evaluated the longevity, survival rates, or clinical performance of glass ionomer cements and composite resin restorations in African populations or populations with similar demographic and epidemiological characteristics. Studies were required to have minimum follow-up periods of 12 months and to report quantitative data on restoration survival, failure rates, or clinical success. Exclusions applied to studies involving indirect restorations, provisional restorations, or populations without documented high caries risk. Additionally, studies focusing exclusively on pediatric or geriatric populations without broader population representation were excluded to ensure applicability across age groups.

### 2.2 Material Properties and Biological Mechanisms

The fundamental distinction between glass ionomer cements and composite resins lies in their chemical composition, polymerization mechanisms, and biological interactions with dental tissues. Glass ionomer cements of both conventional and resin-modified types release fluoride for considerable periods after setting, releasing sufficient fluoride to inhibit the growth of oral bacteria and promote remineralization of tooth mineral. This continuous fluoride release represents a significant therapeutic advantage in high caries-risk populations where preventive measures and access to fluoride-containing dental products may be limited or inconsistent.

The mechanism of fluoride release from glass ionomer cements involves a complex two-stage process that begins with an initial rapid release during the first 24 to 48 hours following material placement, followed by a sustained long-term diffusion phase that can continue for months or even years. Fluoride release from glass ionomers has been shown to increase resistance to acid demineralization, prevent the formation of caries around the restoration, and exhibit antimicrobial activity against Streptococcus mutans, the primary cariogenic bacterium implicated in dental caries initiation and progression. This antimicrobial property is particularly valuable in African populations where dietary patterns may include frequent consumption of fermentable carbohydrates and where oral hygiene practices may be suboptimal due to socioeconomic constraints, limited health education, or cultural factors.

The fluoride reservoir capacity of glass ionomer cements provides an additional dimension of caries protection through the material's ability to absorb fluoride ions from external sources such as fluoridated toothpaste or mouth rinses and subsequently release these ions back into the oral environment. This "recharge" capability ensures that the restorative material continues to provide caries-protective benefits throughout its clinical lifespan, adapting to the fluctuating cariogenic challenges present in the oral cavity. In contrast, composite resin materials, while offering superior mechanical properties and aesthetic characteristics, generally lack significant fluoride release capabilities and do not provide the same level of biochemical caries protection, relying instead on optimal marginal seal and patient compliance with preventive measures to prevent secondary caries development.

### 2.3 Clinical Performance Parameters and Assessment Criteria

The evaluation of restorative material longevity in clinical studies requires comprehensive assessment of multiple parameters that collectively determine restoration success or failure. The United States Public Health Service (USPHS) criteria, also known as modified Ryge criteria, represent the gold standard for clinical evaluation of dental restorations and include assessment of retention, marginal integrity, marginal discoloration, anatomic form, surface texture, color match, and secondary caries development. The Fédération Dentaire Internationale (FDI) criteria provide an alternative evaluation system that categorizes restoration performance into aesthetic, functional, and biological properties, offering a more detailed and clinically relevant assessment framework.

Retention represents the most critical assessment parameter, as complete loss of a restoration necessitates retreatment and exposes the tooth to further caries risk. Marginal integrity evaluates the quality of the restoration-tooth interface, with marginal gaps or ditching providing pathways for bacterial infiltration and subsequent secondary caries development. Secondary caries assessment determines whether new carious lesions have developed adjacent to existing restorations, providing direct evidence of the material's caries-preventive efficacy. Surface characteristics including texture, wear, and anatomic form influence both the functional performance and aesthetic acceptability of restorations, with excessive wear potentially leading to loss of occlusal contacts and altered masticatory function.

Cost-effectiveness analyses provide essential economic perspectives on material selection decisions, particularly in resource-constrained African healthcare systems where budgetary limitations significantly influence treatment choices. Comparative cost-effectiveness studies have shown that the average sealant application time ranged from 5.40 minutes for composite resin to 8.09 minutes for high-viscosity glass ionomer cement, with average costs per sealant ranging from $3.73 for composite resin to $7.50 for glass-carbomer when calculated for 1,000 sealants per group. These time and cost differentials must be considered within the broader context of African dental practice, where dental workforce shortages and high patient volumes require efficient use of limited clinical time and resources.

The economic evaluation of restorative materials extends beyond initial placement costs to encompass the cumulative expenses associated with restoration failures, replacement procedures, and indirect costs including patient travel, lost productivity, and pain management. In many African countries, patients may travel considerable distances to access dental services, with transportation costs and time away from work representing substantial burdens for low-income families. Therefore, restorations with enhanced longevity and reduced failure rates offer compounding economic advantages by minimizing the frequency of dental visits and the associated direct and indirect costs.

## 3. Results and Discussion

### 3.1 Comparative Survival Rates in High Caries-Risk Populations

The comprehensive analysis of available literature reveals complex and nuanced patterns of restoration longevity that challenge simplistic material categorizations. Clinical studies conducted in populations with similar demographic and epidemiological characteristics to African high caries-risk groups have demonstrated that material performance is substantially influenced by cavity configuration, operator skill level, moisture control capabilities, and patient-specific factors including caries activity, oral hygiene practices, and dietary habits.

Systematic reviews comparing high-viscosity glass ionomer cement and composite resin in primary teeth have found no statistically significant differences between these materials in terms of clinical effectiveness and overall survivability, with both materials demonstrating that Class I restorations had statistically higher survival rates than Class II restorations. This finding underscores the importance of cavity configuration as a determinant of restoration longevity, with single-surface restorations subjected to lower occlusal stresses and reduced marginal interfaces compared to multiple-surface restorations that must withstand complex loading patterns and present greater opportunities for marginal breakdown.

The distinction between primary and permanent dentition introduces additional complexity to the comparative evaluation of restorative materials. Primary teeth present unique challenges including thinner enamel and dentin thickness, larger pulp chambers relative to crown size, and the physiological process of root resorption that limits the functional lifespan of restorations regardless of material properties. Long-term follow-up studies have demonstrated that percentage survival rates were significantly higher for all atraumatic restorative treatment using high-viscosity glass ionomer cement restorations at 90.2% compared to conventional resin composite restorations at 82.8% five years after placement, providing compelling evidence for the superior clinical performance of glass ionomer-based approaches in challenging patient populations and clinical circumstances.

**3.2 Fluoride Release and Caries-Preventive Properties**

The caries-preventive capabilities of glass ionomer cements represent a fundamental biological advantage that extends beyond the material's mechanical retention and marginal seal properties. The sustained release of fluoride ions creates a localized protective environment that actively combats the cariogenic challenges present in high-risk populations, providing a level of biological defense that composite resin materials cannot replicate. This distinction becomes particularly significant in African populations where access to fluoridated water supplies remains limited, with only a small percentage of African countries implementing systematic water fluoridation programs, and where commercial fluoridated dental products may be economically inaccessible to substantial portions of the population.

The temporal pattern of fluoride release from glass ionomer cements follows a characteristic biphasic profile, with an initial burst release during the first 24 to 48 hours followed by sustained low-level release that continues for extended periods. This burst effect provides immediate high-concentration fluoride exposure to the adjacent tooth structure, promoting rapid remineralization of partially demineralized enamel and dentin and establishing an antimicrobial environment that inhibits bacterial colonization of the restoration margins. The subsequent sustained release maintains protective fluoride levels in the oral microenvironment, continuously reinforcing the tooth's resistance to acid challenges from cariogenic bacteria and dietary acids.

Research has demonstrated that fluoride concentrations as low as 0.02 parts per million in saliva can shift the demineralization-remineralization balance toward remineralization, with glass ionomer cements capable of maintaining salivary fluoride levels above this threshold for extended periods following restoration placement. In high caries-risk African populations characterized by frequent carbohydrate consumption, irregular oral hygiene practices, and limited professional dental care access, this continuous low-level fluoride exposure provides a passive protective mechanism that operates independent of patient compliance or behavior modification, representing a significant public health advantage for vulnerable communities.

The recharge capability of glass ionomer cements introduces an additional dimension of therapeutic potential that enhances the material's long-term caries-preventive efficacy. When exposed to external fluoride sources such as fluoridated toothpaste, mouth rinses, or professional fluoride applications, glass ionomer restorations can absorb fluoride ions and subsequently release them back into the oral environment, effectively functioning as a fluoride reservoir that amplifies the benefits of topical fluoride interventions. This synergistic relationship between glass ionomer restorations and routine preventive measures creates a comprehensive caries management strategy that is particularly well-suited to community-based oral health programs common in African public health initiatives.

**3.3 Technical Sensitivity and Moisture Tolerance**

The clinical success of dental restorations in resource-limited African settings is substantially influenced by the technical demands of material placement and the environmental conditions under which restorative procedures are performed. Composite resin restorations require meticulous moisture control throughout the bonding and placement procedures, with contamination by saliva, blood, or gingival crevicular fluid during critical bonding steps potentially compromising the restoration's adhesive interface and predisposing to marginal microleakage, secondary caries, and premature failure. The multi-step bonding procedures associated with composite resin placement, including enamel etching, dentin conditioning, primer application, and adhesive polymerization, create multiple opportunities for procedural errors and require substantial operator skill, training, and experience to execute consistently.

In contrast, glass ionomer cements demonstrate remarkable tolerance to moisture during placement, with the acid-base setting reaction actually benefiting from a humid environment during the initial maturation phase. This moisture tolerance proves invaluable in African clinical settings where rubber dam isolation may be impractical due to equipment unavailability, patient cooperation challenges, or time constraints in high-volume public health clinics. The chemical adhesion mechanism of glass ionomer cements, which involves ionic bonding between carboxyl groups of the polyalkenoic acid and calcium ions in the tooth structure, operates effectively in the presence of moisture and does not require the completely dry field essential for composite resin bonding systems.

The simplified placement technique for glass ionomer restorations, particularly in atraumatic restorative treatment applications, enables effective restoration placement by operators with varying levels of training and experience. This accessibility expands the potential dental workforce to include dental therapists, clinical officers, and other mid-level providers who play crucial roles in extending oral healthcare access to underserved African communities. The feasibility of placing glass ionomer restorations in non-traditional settings, including schools, community health centers, and mobile dental clinics, addresses the fundamental challenge of healthcare access that characterizes much of sub-Saharan Africa where dental clinics may be concentrated in urban centers while rural populations face substantial geographical and economic barriers to care.

### 3.4 Application in Atraumatic Restorative Treatment

The atraumatic restorative treatment approach has emerged as a transformative intervention strategy for managing dental caries in African populations, combining minimal intervention philosophy with practical feasibility for implementation in diverse settings ranging from sophisticated urban dental clinics to remote rural communities lacking basic infrastructure. The approach's foundation on manual carious tissue removal using hand instruments eliminates the need for electrical power, compressed air, water spray systems, and the complex infrastructure required for conventional rotary instrumentation, dramatically expanding the potential venues for restorative care delivery.

Implementation studies in Tanzania have demonstrated that the contribution of ART restorations to total dental treatment increased significantly when accompanied by adequate supply of glass ionomer cement and ART hand instruments, with researchers attributing the higher success rate to the structured approach used in introducing ART systematically. This finding emphasizes the importance of comprehensive program planning, training, and logistical support in successful ART implementation, with material availability and instrument accessibility representing critical success factors that must be addressed through sustainable supply chains and governmental commitment to resource allocation.

The psychological benefits of ART extend beyond the technical aspects of restoration placement to encompass patient acceptance and treatment-seeking behavior. The elimination of the dental drill, with its associated noise, vibration, and psychological associations with pain and discomfort, substantially reduces dental anxiety and improves treatment acceptance, particularly among children and individuals with previous negative dental experiences. This reduction in treatment-associated anxiety has important implications for long-term oral health outcomes, as positive early dental experiences establish patterns of regular dental attendance and preventive care utilization that persist throughout the lifespan.

The cost-effectiveness of ART approaches provides compelling economic justification for program expansion in resource-constrained African healthcare systems. The elimination of expensive rotary equipment, the reduced infrastructure requirements, and the ability to train mid-level providers in ART techniques substantially lower the barriers to restorative care provision. These economic advantages must be considered in conjunction with the clinical outcomes data demonstrating comparable or superior longevity for ART restorations compared to conventional approaches, creating a compelling value proposition for policymakers and healthcare administrators seeking to maximize population health outcomes within budgetary constraints.

### 3.5 Challenges and Limitations

Despite the substantial advantages of glass ionomer cements in high caries-risk African populations, the materials present certain limitations that must be acknowledged and addressed through appropriate clinical protocols and case selection. The mechanical properties of glass ionomer cements, while continuously improving through formulation advancements and high-viscosity variants, generally remain inferior to those of composite resins in terms of flexural strength, fracture toughness, and wear resistance. These mechanical limitations become particularly relevant in large restorations subjected to high occlusal stresses, where the risk of bulk fracture or accelerated wear may compromise restoration longevity.

The aesthetic properties of conventional glass ionomer cements, characterized by opacity and limited shade matching capabilities, may prove unsatisfactory for anterior restorations in visible areas where patient aesthetic expectations are high. This aesthetic limitation has stimulated the development of resin-modified glass ionomer cements and giomer materials that combine fluoride release capabilities with improved translucency and color stability, although these hybrid materials introduce complexity to the placement protocol and may sacrifice some of the moisture tolerance advantages of conventional glass ionomers.

The initial setting characteristics of glass ionomer cements require careful clinical management to prevent premature moisture contamination or desiccation during the critical maturation period. The application of protective varnishes or surface coatings during the first 24 hours following placement has become standard protocol to shield the maturing cement from moisture contamination and prevent surface microcracking from dehydration. This additional step, while relatively simple, requires operator awareness and compliance to ensure optimal material performance and represents a potential source of clinical variation in real-world practice settings.

The quality variability among commercially available glass ionomer products creates challenges for evidence-based material selection and procurement decisions in African healthcare systems. Research has demonstrated substantial differences in mechanical properties, fluoride release patterns, and clinical performance among different glass ionomer brands and formulations, with some low-cost alternatives showing inferior performance compared to established products. Studies have found that high-cost glass ionomer brands presented a two-fold-more-likely-to-survive rate compared to low-cost brands, raising important considerations about the true cost-effectiveness of cheaper alternatives when replacement costs and reduced longevity are factored into economic analyses.

## 4. Clinical Recommendations and Implementation Strategies

### 4.1 Evidence-Based Material Selection Guidelines

The development of comprehensive clinical guidelines for restorative material selection in high caries-risk African populations requires integration of multiple factors including patient-specific caries risk assessment, cavity configuration and location, occlusal loading expectations, aesthetic requirements, operator skill level, available equipment and infrastructure, and economic considerations. The evidence synthesis presented in this review supports the following evidence-based recommendations for clinical practice and public health program development.

For single-surface posterior restorations in both primary and permanent teeth in high caries-risk patients, high-viscosity glass ionomer cements represent the material of choice based on their favorable survival rates, fluoride release capabilities, moisture tolerance during placement, and reduced technical sensitivity. The placement of these restorations using atraumatic restorative treatment techniques provides additional advantages in terms of patient acceptance, feasibility in diverse clinical settings, and accessibility to mid-level providers. The application of protective surface coatings or resin sealants over glass ionomer restorations can enhance mechanical properties and extend restoration longevity, creating a layered approach that combines the biological advantages of glass ionomers with the mechanical performance of resin materials.

For multiple-surface posterior restorations, particularly extensive Class II preparations involving proximal boxes and occlusal surfaces, the evidence supports more nuanced decision-making that considers the specific clinical circumstances. In situations where optimal moisture control can be achieved through rubber dam isolation, where operator expertise in adhesive techniques is well-developed, and where high occlusal loading is anticipated, composite resin restorations may offer superior mechanical performance and longevity. However, in high-volume community dental programs, school-based interventions, or outreach settings where technical demands must be minimized and where patient caries risk remains elevated, high-viscosity glass ionomer cements with surface protection represent a pragmatic and clinically effective alternative that prioritizes accessibility and biological caries prevention over maximum mechanical performance.

For anterior restorations where aesthetic considerations predominate, resin-modified glass ionomer cements or giomer materials provide a compromise solution that maintains fluoride release capabilities while improving translucency and color matching compared to conventional glass ionomers. In cases where aesthetic demands are paramount and where patient caries risk can be effectively managed through comprehensive preventive programming including dietary counseling, fluoride supplementation, and enhanced oral hygiene instruction, composite resin restorations remain the treatment of choice for achieving optimal aesthetic outcomes.

For root surface caries, which presents particular challenges in elderly African populations experiencing gingival recession and root exposure, conventional or resin-modified glass ionomer cements demonstrate distinct advantages due to their chemical adhesion to dentin, reduced polymerization shrinkage stress, and fluoride release properties that specifically target the demineralization patterns characteristic of root caries. The location of root surface lesions at or below the gingival margin creates moisture control challenges that favor the use of moisture-tolerant materials, while the reduced occlusal loading on root surfaces minimizes concerns about the mechanical limitations of glass ionomer cements.

### 4.2 Training and Capacity Building Initiatives

The successful implementation of evidence-based restorative strategies in African healthcare systems requires comprehensive training programs that build capacity across multiple levels of the dental workforce. Dental schools and professional training institutions must integrate contemporary minimal intervention dentistry principles, atraumatic restorative treatment techniques, and evidence-based material selection into their curricula, ensuring that graduating practitioners possess the knowledge and skills necessary to implement optimal treatment approaches for high caries-risk populations.

Continuing professional development programs for practicing dentists should emphasize the evolving evidence base regarding restorative material performance, updated clinical protocols, and quality assurance measures that promote consistent clinical outcomes. The establishment of mentorship networks and clinical supervision systems can facilitate knowledge transfer from experienced practitioners to those new to ART techniques or glass ionomer placement, addressing the learning curve associated with mastering material manipulation and clinical judgment regarding appropriate case selection.

The expansion of mid-level dental provider training programs represents a strategic approach to addressing the severe workforce shortages that characterize oral healthcare across Africa. Dental therapists, clinical officers, and oral health practitioners trained specifically in atraumatic restorative treatment and glass ionomer placement can dramatically expand access to restorative care, particularly in rural and underserved areas where dentist availability remains extremely limited. The evidence supporting comparable clinical outcomes for ART restorations placed by appropriately trained mid-level providers compared to dentists provides strong justification for task-shifting policies that maximize the efficient use of limited human resources.

### 4.3 Public Health Program Development

The translation of clinical evidence into population health impact requires the development and implementation of comprehensive oral health programs that integrate restorative care with preventive interventions, health promotion, and policy advocacy. School-based oral health programs represent particularly efficient platforms for delivering restorative care to children, capitalizing on the existing educational infrastructure to provide screening, prevention, and treatment services in familiar and accessible environments. The integration of ART using glass ionomer cements into school health programs has demonstrated feasibility and effectiveness in multiple African countries, with programmatic success depending on sustained governmental commitment, adequate resource allocation, and effective collaboration between health and education sectors.

Community-based programs targeting adults and elderly populations face different implementation challenges related to case-finding, treatment facility requirements, and integration with existing primary healthcare services. The co-location of oral health services with general medical care, maternal and child health programs, and chronic disease management initiatives can improve efficiency and accessibility while promoting a holistic approach to health that recognizes the interconnections between oral health and systemic wellbeing. Mobile dental units equipped for atraumatic restorative treatment can extend services to remote communities, although the sustainability of such programs depends on reliable vehicle maintenance, fuel availability, supply chain management, and trained personnel deployment.

The development of national oral health policies and strategic plans provides essential frameworks for coordinating activities, allocating resources, and monitoring progress toward population health goals. Policy documents should establish clear objectives for reducing untreated caries prevalence, increasing access to restorative care, and addressing oral health inequalities, while identifying the restorative approaches and materials that will receive governmental support and promotion. The inclusion of essential restorative materials, including high-viscosity glass ionomer cements and ART hand instruments, on national essential medicines lists and healthcare procurement frameworks ensures their availability and affordability within public healthcare systems.

## 5. Future Research Directions

### 5.1 Gaps in Current Evidence Base

Despite the substantial body of literature examining glass ionomer cement and composite resin performance, significant knowledge gaps persist that limit the precision of evidence-based recommendations for African populations. Long-term follow-up studies extending beyond five years remain scarce, particularly for studies conducted within African countries that capture the specific environmental, dietary, and population characteristics that influence restoration longevity. The extrapolation of findings from studies conducted in other global regions introduces uncertainty regarding their applicability to African contexts, where factors such as tropical climate conditions, specific dietary patterns, genetic variations in enamel and dentin structure, and disease prevalence patterns may influence clinical outcomes.

The relationship between operator characteristics and restoration survival requires further elucidation, particularly regarding the specific training methods, clinical experience thresholds, and ongoing quality assurance mechanisms that optimize outcomes for different provider types. Understanding which aspects of operator technique most strongly influence restoration longevity can inform training program design and clinical supervision protocols, maximizing the effectiveness of capacity building initiatives.

The economic analyses of restorative approaches in African healthcare systems would benefit from more comprehensive methodologies that capture the full spectrum of costs and benefits including patient-borne expenses, indirect productivity losses, health system administrative costs, and long-term healthcare utilization patterns. Cost-effectiveness analyses conducted from societal perspectives rather than narrow healthcare system perspectives would provide more complete information for policy decision-making and resource allocation.

### 5.2 Emerging Materials and Technologies

The continued evolution of dental materials science presents opportunities for developing next-generation restorative materials that combine the biological advantages of glass ionomer cements with enhanced mechanical properties and aesthetic characteristics. Bioactive glass ionomer formulations incorporating antimicrobial agents, remineralizing ions beyond fluoride, and biocompatible reinforcing particles represent promising areas of investigation that could expand the clinical indications for glass ionomer-based restorations. The development of encapsulated glass ionomer systems with pre-proportioned powder and liquid components addresses concerns about manual mixing variability and could improve consistency of material properties across different operators and settings.

Advances in adhesive technologies, including self-adhesive composite systems and universal adhesives with reduced technique sensitivity, may narrow the gap between glass ionomer and composite resin materials in terms of moisture tolerance and ease of placement. If composite resin systems can approach the moisture tolerance and simplified protocols characteristic of glass ionomers while maintaining their superior mechanical properties, the comparative advantages currently favoring glass ionomers in challenging clinical circumstances may diminish.

Digital dentistry technologies including intraoral scanning, computer-aided design and manufacturing, and 3D printing introduce new possibilities for restorative care delivery, although their relevance to high caries-risk African populations in the near term remains limited by cost and infrastructure requirements. Long-term visioning should consider how emerging technologies might be adapted and scaled for African contexts, potentially through regional fabrication centers serving networks of clinical sites or through development of low-cost, robust systems specifically designed for resource-constrained environments.

## 6. Conclusion

The comparative evaluation of glass ionomer cement and composite resin restorations in high caries-risk African populations reveals a complex landscape where material selection must be informed by multiple interacting factors including clinical performance data, biological mechanisms, technical feasibility, economic considerations, and public health system realities. The evidence synthesized in this review demonstrates that glass ionomer cements, particularly high-viscosity formulations applied through atraumatic restorative treatment approaches, offer substantial advantages for managing dental caries in African populations characterized by elevated disease prevalence, limited healthcare infrastructure, severe workforce shortages, and significant socioeconomic constraints.

The fluoride release properties of glass ionomer cements provide continuous caries-preventive benefits that operate independent of patient compliance or behavior modification, representing a valuable biological advantage in populations with inconsistent access to fluoridated water, limited availability of commercial fluoride products, and challenges with implementing systematic preventive programs. The moisture tolerance and reduced technical sensitivity of glass ionomer placement procedures enable successful restoration placement in challenging clinical environments and by operators with varying skill levels, dramatically expanding the potential for providing restorative care to underserved populations.

Clinical outcomes data demonstrate comparable or superior survival rates for glass ionomer restorations compared to composite resin restorations in many clinical scenarios, particularly when considering the specific circumstances characteristic of African practice settings including limited moisture control capabilities, high-volume patient loads, and the need for treatment approaches accessible to mid-level providers. The cost-effectiveness analyses support glass ionomer-based approaches when considering not only initial material costs but also the broader economic picture including failure rates, replacement procedures, and accessibility considerations.

The successful translation of this evidence into improved population health outcomes requires comprehensive implementation strategies encompassing training and capacity building initiatives, sustainable supply chain management, supportive policy frameworks, and integration of restorative services with preventive programming. The continued evolution of dental materials and treatment approaches promises further improvements in restoration longevity and clinical feasibility, although the fundamental advantages of glass ionomer cements for high caries-risk populations in resource-constrained settings are likely to persist.

Future research should prioritize long-term follow-up studies conducted within African countries, comprehensive economic evaluations from societal perspectives, and investigation of implementation science questions regarding optimal training methods, quality assurance systems, and programmatic models for sustainable service delivery. The ultimate goal remains the achievement of oral health equity, with all populations having access to effective, affordable, and acceptable restorative care that prevents unnecessary tooth loss and preserves oral function, aesthetics, and quality of life throughout the lifespan.

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