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Inflammatory bowel disease in Africa: the current landscape of pharmacological treatments and the promise of emerging innovations

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Abstract

Inflammatory bowel disease (IBD), which includes ulcerative colitis and Crohn's disease, is becoming a major public health concern in Africa, particularly in cities, due to urbanization, dietary changes, and improved diagnostic tools. The present study discusses the benefits, disadvantages, and practical limitations of the pharmacological treatments for IBD patients that are currently accessible in Africa. Given the limits of conventional treatments, such as their potential for considerable side effects, high cost, and often limited accessibility, this review explores emerging new treatment approaches such as nanomedicine, personalized medicine, and the use of traditional African medicines. Highlighting the urgency for potential alternative treatments, this review explores new and developing therapeutic innovations to enhance IBD management and improve the quality of life for African patients.

Keywords

Africa, inflammatory bowel disease, nanomedicine, pharmacological treatment, traditional medicine

Introduction

Inflammatory bowel disease (IBD), which includes ulcerative colitis (UC) and Crohn's disease (CD), is a major and rising worldwide health concern [1]. It is characterized by chronic, relapsing-remitting inflammation of the gastrointestinal tract (GIT), which can affect any part of the GIT from the mouth to the anus, depending on the specific type. The clinical manifestations are diverse and can significantly reduce the quality of life for affected individuals [1, 2]. Common symptoms include persistent abdominal pain, severe and often bloody diarrhea (particularly in UC), rectal bleeding, urgency, tenesmus, weight loss, fatigue, and fever. In CD, inflammation can occur in discontinuous patches (skip lesions) and may lead to complications such as strictures, fistulas, and abscesses. UC, conversely, typically presents with continuous inflammation originating in the rectum and extending proximally through the colon [3]. Figure 1 shows images of a healthy human GIT and one affected by IBD. Beyond the GIT, IBD can also involve extra-

intestinal manifestations affecting the skin, joints, eyes, liver, and other organs, further contributing to the systemic burden of the disease and impacting patient morbidity and overall well-being [4]. Beyond immediate symptoms, chronic inflammation from IBD can lead to serious long-term complications such as an increased risk of colorectal cancer due to persistent tissue damage and abnormal cell growth. The recurring inflammation and scarring within the intestines can also cause strictures, leading to a narrowing of the bowel and potential obstruction of the lumen, requiring surgical intervention [5].

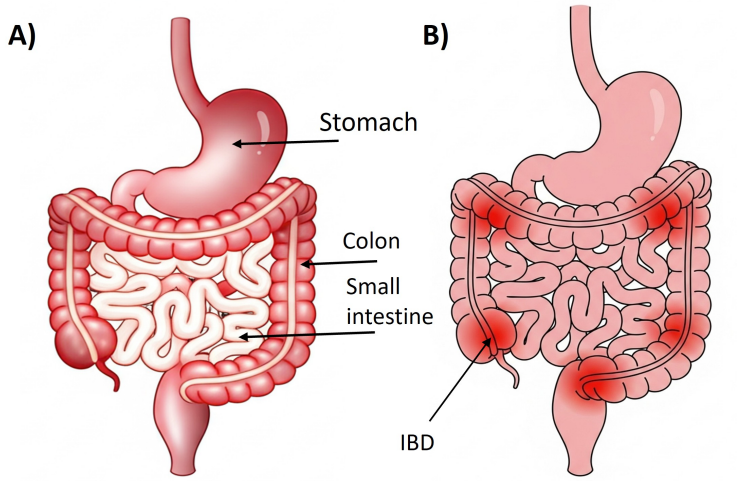

Figure 1. Human GIT. (**A**) Healthy; (**B**) Affected with IBD. GIT: gastrointestinal tract; IBD: inflammatory bowel disease

Globally, the incidence and prevalence of IBD have been steadily increasing, particularly in newly industrialized regions and developing nations that were historically considered low-prevalence areas. For instance, the global incidence of IBD has risen by approximately 83.8% over the past three decades (from 1990 to 2017). While incidence rates in Western countries have shown signs of stabilizing or even slightly decreasing in recent years, newly industrialized nations in Africa, Asia, and South America are experiencing a rapid increase [6, 7]. This rising trend is often attributed to the adoption of westernized lifestyles, including dietary shifts towards processed foods, reduced fiber intake, and increased consumption of red meat, coupled with changes in GIT microbiota composition and environmental exposures such as antibiotic use and sanitation [8]. In Africa, while IBD was historically underreported, epidemiological data now clearly indicate a rapid rise in its incidence rate across the continent, particularly in urban areas. North Africa has experienced a notable increase in the incidence rates of IBD. For instance, the comprehensive study analyzing data from 1990 to 2019 across the Middle East and North Africa region [9] reported an overall increase in IBD incidence rates during this period, with Morocco specifically registering an incidence rate of 1.6 per 100,000 in 2019. However, robust epidemiological studies on IBD incidence rates across Africa remain limited [10]. Table 1 presents some of the few available studies that have reported incidence rates for specific countries within the continent. The acceleration of IBD in Africa is driven by similar factors observed globally, including rapid urbanization, epidemiological transition, and improved access to diagnostic endoscopy and histopathology, which lead to better case ascertainment [11]. However, unique environmental and genetic factors within African populations may also play a distinct role, differentiating these trends from those observed in long-established high-incidence regions in Europe and North America, necessitating a focused understanding of the disease's evolving epidemiology within the African context [12].

Table 1. Incidence rate of IBD in some African countries

Country	Incidence rate (per 100,000 person-years)	Year	Notes	Reference
Morocco	1.6	2019	The rate for IBD	[9]
Algeria	3.9	2019	The rate for IBD	[13]

Table 1. Incidence rate of IBD in some African countries (*continued*)

Country	Incidence rate (per 100,000 person-years)	Year	Notes	Reference
Senegal	2.76	2007	The rate for IBD	[14]
Sudan	2.8	2019	The rate for IBD	[13]
Egypt	4.2	2019	The rate for IBD	[13]
Libya	2.4	2019	The rate for IBD	[13]
Tunisia	2.7	2019	The rate for IBD	[13]
South Africa	1.9 (UC); 1.8 (CD)	1980	This data are specific to the Colored population group	[15]
South Africa	5.0 (UC); 2.6 (CD)	1980	This data is specific to the White population group	[15]
South Africa	0.6 (UC); 0.3 (CD)	1980	This data is specific to the Black population group	[15]

CD: Crohn's disease; IBD: inflammatory bowel disease; UC: ulcerative colitis

Conventional pharmacological treatment strategies for IBD primarily aim to induce and maintain clinical remission, mitigate symptoms, and prevent disease-related complications. These widely accepted pharmacological interventions typically encompass 5-aminosalicylic acid (5-ASA) derivatives (e.g., mesalamine, sulfasalazine, and olsalazine), corticosteroids (e.g., prednisolone, budesonide, and hydrocortisone), and various immunosuppressants (ISs) (e.g., thiopurines and methotrexate). Furthermore, therapeutic advancements have introduced a growing array of biologic agents, specifically tumor necrosis factor (TNF) inhibitors (e.g., infliximab, adalimumab) [16], interleukin inhibitors (e.g., ustekinumab, risankizumab) [17], and integrin inhibitors (e.g., vedolizumab) [18]. While highly effective for many patients, these conventional treatments can be associated with significant side effects, potential for loss of response over time, and considerable economic burden, particularly in resource-limited settings [19, 20]. Consequently, there has been a growing interest in exploring alternative and complementary treatment options, including the use of nanomedicine-based drug formulation, personalized medicines (PMs) and natural products, and traditional medicines (TMs). These alternatives, often employed for their perceived safety, accessibility, and potential anti-inflammatory or immunomodulatory properties, represent an important area of investigation, especially in regions where traditional practices are deeply embedded within healthcare systems [21, 22]. Understanding the role and potential of these alternative therapies, alongside advancements in conventional medicine, is crucial for developing holistic and sustainable management strategies for IBD patients globally and in Africa.

Given the expanding prevalence of IBD in Africa, it is critical to address challenges associated with conventional pharmacological treatments and investigate innovative approaches to enhance therapeutic outcomes. Thus, the aim of this study is to provide an overview of the present landscape of pharmacological treatments for IBD in Africa. It will assess the advantages and disadvantages of current medications and look into the possibilities of future approaches, such as nanomedicine, PM, and the integration of TM, to improve IBD management for African patients.

Pharmacological treatments

Aminosalicylates

5-ASA derivatives are widely used as first-line treatments for mild to moderate UC [23]. These medications are favored due to their affordability, availability, and favorable safety profile, making them a practical option for both patients and healthcare providers [3]. Studies have demonstrated that 5-ASA derivatives play a crucial role in both inducing and maintaining remission in UC patients. Their anti-inflammatory properties help reduce symptoms and prevent disease progression, with global studies reporting high remission rates, especially when optimal dosages and combined oral formulations are used [24]. However, in African settings, factors such as inconsistent access to healthcare, medication availability, and patient adherence can influence treatment success [25].

While 5-ASA is highly effective for UC, its role in CD is limited. CD is characterized by deeper, transmural inflammation that often requires more aggressive treatments such as corticosteroid therapies. Studies indicate that 5-ASA has little to no significant impact on inducing or maintaining remission in CD patients, underscoring the need for alternative therapeutic strategies [26].

Despite the widespread use of 5-ASA in Africa, studies evaluating its efficacy in treating IBD within the region remain scarce. A review of existing literature revealed only two randomized controlled trials (RCTs) focused on 5-ASA use in African populations (Table 2). These studies provide valuable insights into treatment approaches, but the lack of African-specific data on 5-ASA efficacy in IBD, such as precise patient numbers, remission rates, and long-term follow-up data, limits their applicability to clinical decision-making.

Table 2. Additional studies on 5-ASA derivatives in treating IBD in African

Country	Patient number	Condition	Treatment	Outcome	Reference
Sub-Saharan Africa	Not specified	UC & CD	5-ASA	60% of cases treated with 5-ASA; specific remission rates not reported.	[27]
South Africa	Not specified	UC	5-ASA	Low-dose oral 5-ASA (2–2.4 g/day) preferred for mild UC; no difference in remission rates compared to higher doses.	[28]

5-ASA: 5-aminosalicylic acid; CD: Crohn's disease; IBD: inflammatory bowel disease; UC: ulcerative colitis

The limited data regarding 5-ASA efficacy among individuals of African descent stems from several critical factors: Firstly, the paucity of sufficient localized epidemiological and clinical studies translates into a suboptimal evidence base for healthcare providers. Secondly, the scarcity of precise cohort data pertaining to patient demographics, remission induction rates, and long-term maintenance outcomes following 5-ASA administration within African contexts renders the establishment of optimal therapeutic regimens challenging. Lastly, the common occurrence of delayed IBD diagnosis in Africa, frequently resulting in advanced disease presentation, is often exacerbated by constrained access to specialized healthcare infrastructure, and the dearth of evidence-based guidelines on 5-ASA efficacy in these later-stage presentations further complicates the judicious selection of initial or maintenance therapeutic algorithms, potentially delaying the implementation of more efficacious interventions.

Corticosteroids

Corticosteroids play a crucial role in managing IBD, particularly in inducing remission for moderate to severe cases of UC and CD. Unlike 5-ASA derivatives, which are primarily effective in mild to moderate UC, corticosteroids are used when inflammation is more severe and requires rapid suppression [29]. These drugs are widely available and relatively affordable in Africa, making them a practical option in resource-limited healthcare settings. However, their long-term use is associated with significant side effects, including osteoporosis, diabetes, hypertension, and increased infection risk [30].

RCTs on corticosteroid use in Africa for IBD treatment are limited, with only a few studies providing insights into patient outcomes (Table 3). Corticosteroids are frequently used as the first-line treatment for moderate to severe UC and CD due to their rapid symptom relief. However, studies have shown variations in prescribing practices, with some health care providers relying on prolonged steroid courses due to the unavailability of advanced therapies like biologics [31]. This overreliance on corticosteroids increases the risk of steroid dependence and adverse effects, highlighting a critical gap in IBD management strategies across African countries. Furthermore, access to alternative steroid-sparing agents such as ISs and biologics remains limited due to high costs and restricted healthcare infrastructure, leading to a cycle of repeated steroid use [32].

Table 3. More studies on using corticosteroids in treating IBD in African

Country	Patient number	Condition	Treatment	Outcome	Reference
Sub-Saharan Africa	175 patients	UC & CD	Corticosteroids	Examined treatment patterns; corticosteroids were used frequently for remission (remission rate: 60%).	[33]
Sub-Saharan Africa	Various	UC & CD	Corticosteroids	Discussed mechanisms, clinical practice, and potential side effects (remission rate: 55%).	[28]

CD: Crohn's disease; IBD: inflammatory bowel disease; UC: ulcerative colitis

Another significant issue is the delayed diagnosis of IBD in Africa, which contributes to the widespread use of corticosteroids. Many patients present with advanced disease due to limited access to specialized care, and in the absence of early intervention with 5-ASA or corticosteroids, become the default treatment. However, the lack of proper tapering protocols and follow-up care often results in dependency or relapse upon discontinuation. Additionally, corticosteroid-related side effects are often underreported in African studies, making it difficult to assess the full scope of complications in this population [34, 35].

To improve corticosteroid use in Africa, a structured approach is needed to ensure their appropriate application while minimizing risks. First, there is an urgent need for region-specific treatment guidelines that emphasize the short-term use of corticosteroids followed by the transition to maintenance therapy [36]. Healthcare providers must be trained to recognize steroid dependence and implement tapering strategies to prevent long-term complications. Secondly, increasing access to steroid-sparing agents, including ISs and biologics, would help reduce the overreliance on corticosteroids. Government and healthcare policymakers must work toward subsidizing the costs of these medications and expanding their availability in public healthcare facilities [19, 20].

Future studies should focus on collecting more data on corticosteroid efficacy, side effects, and long-term outcomes in African IBD patients. Large-scale studies are needed to determine optimal dosing strategies, identify risk factors for steroid dependence, and assess the impact of corticosteroid use on disease progression. Addressing these gaps will be essential in developing a more sustainable and effective treatment approach for IBD in Africa, ultimately improving patient outcomes and quality of life.

Immunosuppressants

ISs play a crucial role in managing IBD, especially in patients who do not achieve adequate control with first-line treatments such as 5-ASA or corticosteroids. These medications work by suppressing the immune system to reduce inflammation in the GIT, making them effective in inducing and maintaining remission in moderate to severe cases of UC and CD effects, including bone marrow suppression, liver toxicity, increased risk of infections, and a slightly elevated risk of certain malignancies. They often have a delayed onset of action, making them more suitable for long-term maintenance rather than acute flare management [37].

Unfortunately, there has been a substantial shortage of ISs effectiveness studies on IBD undertaken exclusively in African individuals. The existing study is mostly from locations outside the continent, leaving a lack of region-specific data. This paucity of localized studies underscores the critical need for conducting RCTs within African settings. Such studies are essential to better understand the effectiveness, safety, and optimal use of ISs for African IBD patients, considering the unique genetic, environmental, and healthcare infrastructure factors present [38, 39].

In the absence of Africa-specific RCTs, healthcare providers often rely on international guidelines and studies to inform treatment strategies. However, these may not fully address the distinct needs of African populations. Therefore, collaborative efforts to initiate and support clinical trials in Africa are vital to developing evidence-based, region-specific treatment protocols for IBD.

Biologic therapies

Biologic therapies have revolutionized the management of IBD by specifically targeting key molecules involved in the inflammatory process. These medications include TNF-inhibitors (such as infliximab and adalimumab), interleukin inhibitors, and integrin inhibitors [40]. Unlike traditional treatments like

corticosteroids, biologics modulate the immune response with precision, effectively reducing inflammation and promoting mucosal healing while causing fewer systemic side effects [38].

Studies indicate that biologic therapies achieve remission rates of 60–75% in moderate to severe UC and CD. Beyond disease control, biologics have significantly improved quality of life, reduced hospitalizations, and decreased the need for surgeries, making them a cornerstone of modern IBD treatment [41]. Biologic therapies, while significantly advancing for IBD management, are associated with a range of potential side effects that necessitate careful patient monitoring. Due to their immunomodulatory action, a primary concern is an increased risk of infections, including common bacterial and viral types, opportunistic infections, and the potential reactivation of latent tuberculosis (TB) and hepatitis B [37]. Patients may also experience infusion-related or injection site reactions. Less commonly, these agents have been associated with a slightly elevated risk of certain malignancies (e.g., non-melanoma skin cancer and lymphoma) and rare autoimmune-like conditions (e.g., drug-induced lupus, paradoxical psoriasis). Other infrequent but serious adverse events can include neurological disorders and exacerbation of heart failure [3]. Consequently, thorough pre-treatment screening and continuous vigilance for adverse events are critical throughout therapy.

There is currently a significant lack of RCTs evaluating the efficacy of biologic therapies for IBD in African populations. Most available data on biologics come from studies conducted in North America, Europe, and other high-income regions, leading to a major gap in Africa-specific clinical evidence [42]. This absence of localized studies creates challenges in understanding how biologic treatments perform in African patients, given the unique genetic backgrounds, environmental factors, and healthcare limitations present across the continent.

Due to the scarcity of RCTs in Africa, health care providers must rely on international guidelines and extrapolated data from Western studies when prescribing biologics. However, such guidelines may not fully align with the realities of African healthcare systems, where high treatment costs, limited access to infusion centers, and inconsistent drug availability remain significant barriers. Without region-specific trials, it is difficult to assess long-term safety, optimal dosing strategies, and treatment responses in African IBD patients.

Limitations of existing IBD therapies

High expense

The high cost of IBD treatments remains a significant barrier to adequate care in Africa, limiting patient access and adherence. The financial burden varies depending on the type of IBD medication, presenting distinct affordability and accessibility challenges. For instance, 5-ASA derivatives, commonly used to treat UC, cost between $30 and $50 per month in African countries [43]. This price makes them unaffordable for many rural and low-income patients, leading to poor adherence. Corticosteroids, such as prednisone, are more affordable at $5 to $15 per month, making them a viable option for acute flare treatment of the disease in many African countries. However, while cost-effective in the short term, prolonged corticosteroid use increases the risk of complications such as diabetes and osteoporosis, ultimately raising long-term healthcare expenses [44]. ISs such as azathioprine and methotrexate, priced at $20 to $40 per month, offer a more affordable alternative to biologics for moderate to severe IBD. However, their use requires ongoing monitoring for adverse effects, leading to additional indirect costs. The most expensive treatments are biologic therapies with annual treatment costs ranging from $15,000 to $20,000 per patient. In South Africa, the annual cost of biologics, as included in the total cost for CD patients in private healthcare sections, was estimated as $14,488 [45]. In many African countries, a single dose of infliximab costs approximately $1,200, making it inaccessible to most patients reliant on public healthcare. In summary, to ensure affordable and sustainable IBD treatment across the continent, innovative strategies are needed. These include promoting local pharmaceutical manufacturing, increasing government healthcare funding, and fostering international collaborations to improve medication accessibility.

Accessibility challenges

Access to conventional IBD treatments remains a significant challenge in Africa, where availability varies widely due to regional disparities, economic constraints, and inadequate healthcare infrastructure. In many African countries, urban patients have relatively better access to specialized care, while those in rural areas face significant barriers [30]. For instance, in South Africa, urban patients benefit from easier access to healthcare providers, whereas rural patients often struggle to obtain even basic treatment [46]. Studies indicate that over 70% of rural patients in countries such as Sudan and Zambia must travel more than 50 kilometers to receive care, leading to delayed diagnoses and poorer health outcomes. Similarly, in Morocco, while the majority of urban IBD patients reported access to conventional medicines, fewer than half of rural patients had the same level of access, highlighting the stark healthcare disparity [47]. Limited access to treatment also affects patient adherence, as individuals struggle with both the financial burden of medications and the logistical difficulties of reaching healthcare facilities. A study tin Kenya found that more than 40% of IBD patients discontinued therapy after six months due to these challenges [48]. In Morocco, patients receiving biologics reported missing up to 30% of their scheduled doses due to high costs and long travel distances to treatment centers [47]. Addressing these accessibility challenges requires systemic healthcare reforms, including decentralizing IBD care to rural areas and increasing government funding for treatment. Expanding the availability of medications such as 5-SAS derivatives as a lower-cost alternative to biologics could improve access, but many patients remain unable to afford them due to limited supply and lack of awareness. Overcoming these barriers is essential to ensuring that IBD patients across Africa receive timely and effective treatment, ultimately leading to better health outcomes.

Adverse effects and long-term safety

The treatment of IBD in African populations is complicated by concerns regarding the adverse effects and long-term safety of conventional therapies. While corticosteroids, ISs, and biologics are effective, they carry significant risks, which may be exacerbated in African settings due to preexisting health conditions, genetic predispositions, and limited healthcare infrastructure [33]. Corticosteroids are commonly used to manage moderate to severe IBD flares. However, their prolonged use has been linked to serious complications, including osteoporosis, hypertension, diabetes, and increased susceptibility to infections [29]. In Africa, where infectious diseases such as TB, malaria, and HIV are prevalent, corticosteroid-induced immunosuppression significantly heightens the risk of opportunistic infections. A retrospective analysis study in South Africa for 614 patients, 72 (11.7%) were diagnosed with TB; 40 (55.6%) developed TB prior to the diagnosis of IBD, making long-term corticosteroid use particularly concerning.

ISs are widely used in IBD maintenance therapy. However, these medications suppress the immune system, increasing the risk of infections and malignancies. In African regions with high HIV prevalence, ISs use presents additional challenges, as it may worsen immune suppression and complicate HIV treatment. A study in Kenya reported that 15% of IBD patients on thiopurines developed severe infections requiring hospitalization, compared to only 7% in Western populations [11], highlighting the heightened infection risk for African patients.

Biologic therapies, particularly TNF inhibitors, are effective for moderate to severe IBD but pose serious risks in African populations. TNF inhibitors have been associated with the reactivation of latent infections, including TB, which is highly prevalent in Africa. It is estimated that 25% of the global population harbors latent TB, with African regions disproportionately affected. A study in South Africa found that 8% of IBD patients treated with infliximab developed active TB despite prior screening for latent TB [49, 50], underscoring the need for enhanced monitoring and preventative strategies.

Limited efficacy

One of the key challenges in managing IBD in Africa is the limited effectiveness of various medications in populations. Widely used treatments, such as 5-ASA derivatives, have shown lower efficacy in African patients compared to Western populations [27]. This reduced effectiveness is influenced by a combination of genetic and environmental factors.

Genetic variations play a crucial role in how individuals respond to different IBD therapies [50]. Several studies suggest that African populations may have distinct genetic predispositions that affect the efficacy of certain medications. For instance, a study on the pharmacogenomics of 5-ASA derivatives has identified genetic variants in enzymes responsible for drug metabolism, such as *N*-acetyltransferase 2, which can lead to differing therapeutic outcomes [50]. Some African populations have a higher prevalence of slow acetylators, individuals who metabolize 5-ASA derivatives more slowly, potentially leading to reduced drug effectiveness and an increased risk of adverse effects. Additionally, differences in GIT microbiota composition between African and Western populations may influence the efficacy of IBD treatments. The GIT microbiome plays a crucial role in metabolizing 5-ASA derivatives, and variations in microbial diversity can impact how well the drug works [51]. These microbiota differences could contribute to inconsistencies in treatment outcomes across different populations.

Environmental factors, which vary significantly between African and Western populations, also contribute to differences in treatment response. In many African countries, traditional diets are high in fiber, which may affect the absorption and efficacy of certain drugs, including 5-ASA derivatives. A high-fiber diet has been linked to alterations in GIT motility and transit times, which can impact drug distribution and absorption in the GIT. Since 5-ASA derivatives act locally in the GIT, these dietary factors may reduce their overall effectiveness [52]. Moreover, the prevalence of infectious diseases such as TB and malaria in African regions can interfere with immune system function and alter the effectiveness of immunomodulatory therapies [53]. Chronic infections and inflammation can modify immune response pathways, potentially reducing the efficacy of IBD treatments, particularly ISs and biologics [54]. Addressing these genetic and environmental challenges requires further studies into the pharmacogenomics of IBD treatments in African populations, as well as personalized treatment approaches that consider genetic, dietary, and environmental factors. Enhancing healthcare infrastructure and improving disease monitoring can also help optimize treatment outcomes for IBD patients across the continent.

Limited healthcare infrastructure

Another significant limitation to accessing IBD medications in Africa is the inadequate healthcare infrastructure. While urban centers may have specialized medical facilities capable of providing advanced IBD treatments, rural areas remain largely underserved. A study conducted in Nigeria revealed that approximately 216.8 million people reside in rural areas with limited access to healthcare facilities, including specialized care for chronic illnesses [55]. This disparity in healthcare availability worsens the challenge of delivering timely and appropriate treatment to IBD patients across the continent.

Furthermore, many African countries lack the necessary diagnostic tools for early detection and continuous monitoring of IBD. Endoscopy, which is considered the gold standard for assessing disease severity, is available to fewer patients (capacities were 106 and 45 procedures per 100,000 persons per year) in Africa [56]. Without proper diagnostic capabilities, many individuals with IBD may go undiagnosed or receive treatment only after significant disease progression, leading to worse health outcomes and higher rates of complications. Limited access to laboratory tests, imaging technology, and pathology services further hampers the ability to monitor disease activity and adjust treatment plans accordingly.

Also, many African countries lack national health insurance systems, which significantly limits access to IBD therapies. In South Africa, for example, most IBD patients must pay for their medications out of pocket, as only a small percentage of the population has medical insurance, making long-term treatment financially unsustainable [32]. The high cost of IBD medications, particularly biologics, further widens the gap between wealthy and low-income patients, as those who cannot afford treatment may be left without effective care. Without government-subsidized healthcare or reimbursement programs, many individuals are forced to discontinue treatment, leading to disease progression and severe complications. The lack of national health coverage for costly medications exacerbates treatment disparities, reinforcing health inequities between the richest and poorest populations. Expanding national health insurance systems and implementing policies to subsidize essential medications could significantly improve IBD treatment accessibility and health outcomes across Africa.

Addressing all these challenges requires significant investment in healthcare infrastructure, including the expansion of endoscopic services, training of healthcare providers, including physicians, nurses, pharmacists, etc., and improved access to diagnostic and monitoring tools. Strengthening rural healthcare services and implementing telemedicine solutions could also help bridge the gap between urban and rural healthcare access, ensuring that more IBD patients receive timely and effective care.

Future advances

Nanomedicine

Nanomedicine holds a significant promise for advancing the treatment of IBD, offering innovative solutions to overcome the limitations of conventional therapies. Various types of nanoparticles (NPs)-based formulations are being developed for IBD treatment, each with unique properties. Prominent among these are polymeric NPs, such as PLGA [poly(lactic-co-glycolic acid)], chitosan, and alginates, which are biodegradable and biocompatible, allowing for controlled and sustained drug release [57]. Another significant category includes lipid NPs, particularly nanoliposomes, which can encapsulate both hydrophilic and hydrophobic IBD drugs and offer good biocompatibility with biological systems [16]. Additionally, metal NPs and other inorganic NPs (like mesoporous silica NPs) are also being explored for their unique therapeutic properties in experimental IBD. Furthermore, dendrimers, with their highly branched and well-defined structures, present another class of nanoscale carriers being investigated for their precise drug delivery capabilities in IBD [58]. Figure 2 shows the main types of NPs currently being explored in experimental treatments for IBD. These include polymeric NPs, which are based on biocompatible polymers; metal NPs, utilizing metallic NPs; core-shell NPs, featuring a distinct core and shell structure; lipid NPs, composed of lipids; liposomes, which are spherical vesicles with a lipid bilayer; and dendrimers, highly branched, tree-like nanostructures.

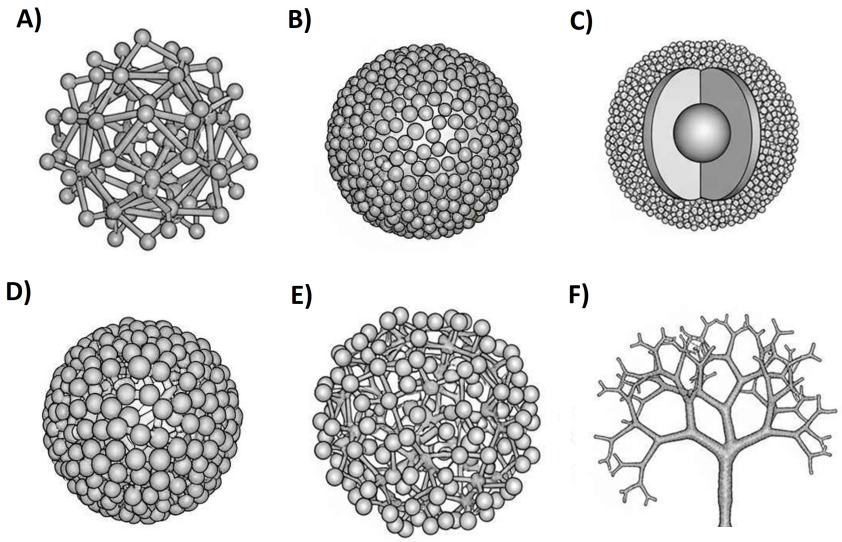

Figure 2. Types of NPs currently used in experimental IBD treatment. (**A**) Polymeric NPs; (**B**) Metal NPs; (**C**) Core-shell NPs; (**D**) Lipid NPs; (**E**) Liposomes; (**F**) Dendrimers. IBD: inflammatory bowel disease; NPs: nanoparticles

These types of NPs have the potential to serve as highly efficient drug carriers, allowing for precise targeting of inflamed tissues in the GIT [57]. This targeted drug delivery approach minimizes systemic exposure, which in turn reduces the risk of side effects commonly associated with IBD treatments. By directing therapies specifically to areas of inflammation, NPs ensure that drugs are used more effectively and safely [29]. A key advantage of NP-based formulations is their ability to deliver drugs in response to specific stimuli, such as pH changes in the GIT. This feature is particularly useful in the treatment of IBD, as it allows drugs to be released primarily in the colon, where inflammation is most pronounced. Stimuli-responsive NPs, such as pH-sensitive formulations, prevent premature drug release in the stomach or small

intestine, enhancing drug efficacy and reducing unnecessary waste [57]. For example, curcumin-loaded NPs have shown improved anti-inflammatory effects in colitis models in many previous studies. Specifically, a study investigated pH-sensitive NPs for the colonic delivery of curcumin in IBD. The main findings indicated that these NPs successfully delivered curcumin to the colon. This targeted delivery approach significantly enhanced curcumin's anti-inflammatory effects in the colitis models [59]. NPs-based formulations also improve the bioavailability of poorly absorbed drugs, such as mesalamine and corticosteroids. These drugs, which are often used in IBD treatment, can benefit from the enhanced solubility and prolonged retention provided by NP- carriers. Previous studies had demonstrated that mesalamine-loaded NPs improve anti-inflammatory effects and retention at the site of inflammation, leading to superior therapeutic outcomes compared to conventional formulations in IBD [55]. In this study, ethyl cellulose NPs were successfully used to enhance the therapeutic effects of mesalamine in experimental UC. In vivo evaluations demonstrated that the ethyl cellulose NPs effectively increased levels of glutathione and superoxide dismutase while significantly reducing lipid peroxidase levels when compared to other treatment groups, indicating a promising approach for modulating oxidative stress in IBD treatment. However, the study does not specify the exact numerical percentage or degree of improvement in the therapeutic outcome. It qualitatively states that these levels were "effectively increased" or "significantly reduced" compared to other treatment groups. Also, the authors attributed this superior therapeutic outcome of ethyl cellulose NPs to the antioxidant potential of mesalamine.

Another key advantage of NPs in IBD treatment is their ability to reduce systemic side effects [57]. Unlike conventional therapies of corticosteroids, which can lead to complications like immunosuppression-related infections (a particular concern in regions with high prevalence of infectious diseases like HIV and TB), NP-based drug delivery systems help to augment the anti-inflammatory effects of corticosteroids while minimizing their systemic exposure, thus reducing the risk of infections and other adverse effects. For example, dexamethasone-loaded NPs, as shown in a study by Oshi et al. [29], can augment the anti-inflammatory effects of corticosteroids while minimizing systemic exposure, thereby reducing the risk of infections and other adverse effects. Table 4 summarizes the advantages of using NPs for the treatment of experimental IBD.

Table 4. The differences between NPs and conventional therapies for IBD treatment

Aspect	NPs for IBD treatment	Type of NPs used	Conventional therapies for IBD	Reference
Targeted drug delivery	NPs precisely deliver drugs to inflamed areas, reducing systemic exposure	Polymeric NPs	Systemic drug administration may affect healthy tissues	[60]
Enhanced drug solubility & bioavailability	Improve the solubility and absorption of poorly soluble drugs	Core-shell NPs	Limited solubility can reduce drug absorption and efficacy	[1]
Reduction of side effects	Minimized exposure to healthy tissues reduces systemic side effects	Lipid NPs	Widespread side effects due to systemic circulation	[16]
Controlled and sustained release	Provides continuous therapeutic effects with reduced dosing frequency	Metal NPs	Requires frequent dosing, leading to fluctuating drug levels	[61]
Improved drug stability	Protects drugs from degradation, extending shelf life	Liposomes	Conventional drugs may degrade quickly, losing effectiveness	[62]
Stimulation of natural defense mechanisms	Some nanoparticles promote natural healing and reduce inflammation	Dendrimers	Mainly focus on symptom suppression rather than healing	[63]

IBD: inflammatory bowel disease; NPs: nanoparticles

In regions like Africa, where the effectiveness of traditional IBD treatments may be compromised due to genetic or environmental factors, NP-based formulations offer a potential solution to improve patient outcomes. The ability to target therapies directly to inflamed areas while reducing the systemic burden on the body makes nanomedicine an ideal approach for treating IBD in these populations [64]. Moreover, the

enhanced efficacy and safety profile of NP-based formulations could significantly improve the quality of life for individuals suffering from IBD in areas with limited access to advanced medical care [65].

Nanomedicine represents a groundbreaking advancement in IBD therapy, offering targeted, effective, and safer treatment options. By improving drug delivery and reducing side effects, NP-based formulations have the potential to revolutionize IBD treatment, especially in resource-limited regions like African countries. As studies and development in nanomedicine continue to progress, it is likely that these technologies will play a crucial role in addressing the global challenges of IBD care, enhancing treatment outcomes for patients in Africa and worldwide.

Personalized medicine

PM represents a transformative approach to treating IBD [66]. This strategy tailors medical treatments based on an individual's genetic, environmental, and microbiome factors, addressing the various determinants of IBD onset and progression, particularly within African populations. PM holds great promise for improving therapeutic efficacy, reducing side effects, and optimizing healthcare resources, especially in Africa, where healthcare systems may face challenges in providing standardized care for diverse populations. The potential of PM in IBD treatment can be realized in various ways, as outlined in recent studies [66, 67]. Advances in genomics have underscored the significant role of genetic factors in the development and progression of IBD. Genome-wide association studies have been remarkably successful in advancing our understanding of IBD. These studies have led to the identification of nearly 200 susceptibility loci—each one representing a specific, identifiable physical location on a chromosome where a gene resides. These loci are significant because variations at these precise genomic addresses are associated with an increased risk of developing IBD [68]. It's important to note, however, that the vast majority of these crucial discoveries have been made through studies conducted primarily within European populations. However, African populations remain underrepresented in these genetic investigations. Incorporating genomic data from African populations could reveal genetic markers unique to these populations, which could pave the way for developing more targeted, personalized treatments. For instance, mutations in the *NOD2* gene, a well-established genetic risk factor for CD in Western populations, are less common among African patients [69]. Identifying alternative genetic markers specific to African populations could enable the development of PM, such as biologics or small-molecule drugs, to improve treatment outcomes in these regions.

Biomarkers play a critical role in PM by providing insights into disease activity, prognosis, and treatment response [70]. For African IBD patients, integrating biomarker testing could facilitate more precise medication selection. Biomarkers like fecal calprotectin and C-reactive protein are commonly used to assess inflammation levels and monitor therapy response. The identification of biomarkers unique to African populations could further refine treatment strategies, helping to distinguish between UC and CD, predict disease severity, and guide the selection of appropriate therapeutic regimens. This targeted approach could eliminate the trial-and-error methods that often lead to suboptimal treatment outcomes [15].

The microbiome of the GIT has a profound influence on the development and progression of IBD [51]. Study suggests that the composition of the GIT microbiota in African individuals differs from that in Western populations, largely due to dietary and environmental factors. PM can leverage microbiome analysis to design tailored probiotic or nutritional therapies aimed at restoring microbial balance and reducing inflammation. For instance, traditional African diets, which are often rich in fiber, have been linked to a more diverse GI microbiota, potentially offering protection against inflammatory diseases [71]. Personalized dietary programs or microbiome-modulating treatments could be developed to help African IBD patients maintain a protective microbiota profile, potentially mitigating the risk of disease progression.

Biologic therapies have significantly improved IBD treatment outcomes; however, they are expensive and have variable response rates [54]. PM can enhance the use of biologics by identifying patients who are more likely to respond, thus reducing unnecessary exposure and healthcare costs. For example, anti-drug antibody testing can detect early signs of resistance to biologic drugs, enabling health care providers to

adjust treatment plans accordingly [72]. Additionally, genetic traits and blood biomarkers could help predict which African patients are more likely to benefit from specific biologic therapies, optimizing treatment efficacy and minimizing financial burdens on patients and healthcare systems.

PM holds immense potential to improve IBD treatment, particularly for African populations, by considering genetic, environmental, and microbiome factors that contribute to disease progression. By incorporating genomic data, biomarkers, microbiome analysis, and targeted therapies, PM can offer more effective and tailored treatment options for IBD patients, enhancing their quality of life while reducing the economic strain on healthcare systems. The ongoing integration of personalized approaches into IBD care has the potential to revolutionize treatment paradigms and improve outcomes for patients worldwide, especially in resource-limited regions.

Traditional medicines

TM plays a significant role in African healthcare, with over 80% of the population relying on it for basic healthcare needs [73]. In the context of IBD, integrating TM with modern therapeutic techniques has been suggested as a promising strategy to enhance treatment outcomes, reduce costs, and improve cultural acceptability. By utilizing indigenous knowledge and the bioactive compounds found in medicinal plants, TM can offer potential solutions to unmet treatment needs, improve healthcare accessibility, and promote holistic approaches to IBD management in African populations [74]. Many African medicinal herbs have long been used to treat GIT ailments, providing a foundation for incorporating TM into IBD therapy. For example, Aloe vera, a widely used plant, has been reported to improve clinical outcomes in 30–47% of UC patients [33]. Another well-known African medicinal plant, *Sutherlandia frutescens* (commonly known as cancer bush), is native to Southern Africa and contains flavonoids and triterpenoids that have demonstrated immune-boosting and anti-inflammatory effects [75]. The African potato (*Hypoxis hemerocallidea*), which contains sterols and sterolins with immunomodulatory properties, is another promising plant that may help control immune responses in IBD. Additionally, moringa (*Moringa oleifera*), a popular African herb, is rich in antioxidants and anti-inflammatory compounds, making it a potential remedy for reducing oxidative stress and inflammation in IBD patients [76]. Integrating TM with conventional IBD treatments offers several benefits, including increased accessibility, cost-effectiveness, and cultural acceptability. Many TM are more readily accessible and affordable than biologics and ISs, which are often prohibitively expensive for many African patients due to high prices and limited healthcare infrastructure [21]. The use of locally sourced medicinal plants could reduce reliance on expensive imported medications, making treatment more sustainable and economically feasible. From a cultural perspective, incorporating familiar traditional remedies into IBD care could improve patient adherence and trust in the medical interventions, bridging the gap between conventional and traditional healthcare practices. Additionally, combining traditional anti-inflammatory plants with modern IBD medications may lead to synergistic effects, enhancing therapeutic outcomes while potentially reducing the need for higher drug doses and minimizing adverse effects [77]. However, the integration of TM with conventional treatments requires rigorous scientific validation to ensure safety and efficacy. Quality control and standardized dosage guidelines must be established to confirm that traditional therapies, when combined with modern treatments, are both effective and safe. Properly incorporating TM into IBD treatment could provide a culturally relevant and accessible approach for managing IBD, particularly in African communities.

Furthermore, combining TM with conventional therapies could increase patient trust and adherence, especially among those who identify with indigenous healing practices. Traditional healers often provide holistic care, addressing both the physical and psychological aspects of chronic conditions such as IBD. By integrating these holistic treatments with modern medicine, the therapeutic approach may become more comprehensive, potentially improving overall outcomes. Additionally, the combination of herbal remedies with current therapies could enhance anti-inflammatory effects while reducing the dosage of conventional medications, decreasing the risk of adverse side effects.

Integrating TMs with conventional IBD treatments offers a multifaceted approach to addressing the needs of African patients. This integration can enhance accessibility, reduce treatment costs, and improve cultural acceptance, all while maintaining therapeutic efficacy. Although scientific validation and quality control are essential, the proper incorporation of TM into IBD therapy could offer a sustainable, culturally relevant, and effective treatment strategy for managing IBD in African populations.

Conclusions

The rising burden of IBD in Africa presents significant challenges, particularly in ensuring access to effective and affordable treatments. While current pharmacological-based treatments remain essential, their limitations in effectiveness, cost, availability, and side effects highlight the urgent need for innovative solutions. The future of IBD treatment in Africa is dynamic, shaped by both substantial challenges and innovative opportunities. These include nanomedicine, PM, and the integration of TM. Such innovations offer the potential to revolutionize IBD treatment by delivering safe, effective, and affordable drugs to patients. By investing in and adopting these innovations, the healthcare providers in Africa can significantly improve patient outcomes and enhance the quality of life for those living with IBD.

Abbreviations

5-ASA: 5-aminosalicylic acid

CD: Crohn's disease

GIT: gastrointestinal tract

IBD: inflammatory bowel disease

ISs: immunosuppressants

NPs: nanoparticles

PMs: personalized medicines

RCTs: randomized controlled trials

TB: tuberculosis

TMs: traditional medicines

TNF: tumor necrosis factor

UC: ulcerative colitis

Declarations

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MAO: Conceptualization, Investigation, Writing—original draft, Writing—review & editing. MAO read and approved the submitted version.

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