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Colon and Rectal Cancer Management in Low-Resource Settings

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Abstract

Colorectal cancer (CRC) incidence is rising in low- and middle-income countries, which also face disproportionate mortality from CRC, mainly due to diagnosis at late stages. Various challenges to CRC care exist at multiple societal levels in underserved populations. In this article, barriers to CRC care, strategies for screening, and treatment in resource-limited settings, and future directions are discussed within a global context.

Keywords
- colorectal cancer
- global surgery
- low-resource setting
- surveillance
- treatment

Colorectal cancer (CRC) is the third most diagnosed cancer and second leading cause of cancer-related death worldwide.[1] In 2020, an estimated 1.9 million people were diagnosed with CRC and 940,000 deaths were attributed to CRC.[2] The global incidence of CRC is predicted to increase to approximately 3.2 million cases by 2040.[2] While the incidence of CRC is on average sixfold higher in high-income countries compared with very low-income countries, there have been distinct shifts over the past decade in the incidence and mortality of CRC across the globe that correlate with measures of development, including human-development index (HDI) and socio-demographic index levels.[1,3] The incidence and mortality of CRC are rising in low- and medium-HDI countries (Eastern Europe, Asia, South America), while the incidence and mortality are stabilizing or decreasing in countries with the highest HDI (United States, Australia, New Zealand, Western Europe).[3]

The global rise of CRC incidence is multifactorial. Rapid increases in wealth and economic development in low- and middle-income countries have led to increased exposure to CRC risk factors including westernization of diet, resulting in consumption of more red and processed meats, refined sugars, and less intake of fruits, vegetables, and fiber.[4] Smoking, alcohol use, sedentary lifestyle, and obesity are also thought to contribute. Increased mortality in low- and middle-income countries may be associated with limited access to CRC screening resulting in delayed diagnosis, lack of access to adjunct therapies such as chemotherapy and radiation, as well as health and cultural beliefs. Meanwhile, the declining mortality in high-income countries can be in part attributed to more developed health care systems that provide widespread screening programs and deliver best practices in CRC treatment.

These global trends point toward a widening disparity gap in low- and middle-income countries that are undergoing economic and societal development, but still do not possess the infrastructure for effective widespread screening and best practice therapy for CRC. The rapid rise in CRC cases represents a critical public health issue. In this article, we will review barriers to care, screening and treatment approaches, and ongoing developments in CRC care in low-resource settings.

Societal Implications and Barriers to Care

Barriers to evidence-based screening and treatment contribute to poor outcomes of CRC seen in low- and middle-income countries. Identifying these barriers and developing strategies to address them can lead to implementation of more widely adopted screening and treatment programs. These barriers are context and culture specific, and not all resource-restricted health systems will face the same challenges. Efforts to tailor CRC screening and treatment programs will depend on a variety of context-specific factors such as socio-demographics, religious and cultural norms, and health care infrastructure. A qualitative analysis conducted

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on a low-income, urban community in Mexico City identified barriers at multiple levels to implementation of a non-invasive CRC screening program[5]; at a societal level, they identified poverty, health literacy, and beliefs around health, cancer, medicine, and gender as major barriers. For example, participants often shared the view that cancer was a "death sentence."[5] At a health care system level, lack of CRC awareness among health care providers, lack of infrastructure, community perceptions around the quality of available health care, poor doctor–patient communication, and previous experiences of mistreatment and abuse in health care were found to be major challenges. Finally, at the individual level, the authors found a lack of CRC awareness, fear of participating in screening, and distrust in health care providers; and concluded that implementation of CRC screening in this population would be facilitated by enhanced education of health care personnel and community members on CRC and its screening options, free screening, as well as culturally-appropriate, non-fear-based screening messages tailored to lay beliefs.[5]

A study investigating clinician perspectives on using evidence-based CRC treatment guidelines conducted in Ukraine, where CRC incidence is rising and mortality rates remain high, demonstrated lack of English proficiency and financial constraints as significant barriers to using the most updated CRC treatment guidelines among Ukrainian surgeons.[6] The authors proposed that open-access literature and foreign language translation should be made available via international societies to low- and middle-income countries.[6]

Populations underserved in CRC care also exist within rural settings in the United States. Disparities in CRC screening were identified in a population-based study that compared breast and CRC screening among women living in rural versus urban areas in the United States.[7] Women in rural and urban communities were equally adherent to breast cancer screening, however, women living in rural areas were significantly less likely to be adherent to CRC screening (82 vs. 78%, $p = 0.01$).[7] Women living in rural areas were found to have lower income and level of education, higher rate of smoking, and less frequent use of health care than women residing in urban areas. They also identified more fatalistic beliefs around cancer among the rural population and skepticism around the use of screening. The authors hypothesized that the disparities in CRC screening among rural women are partially due to slower diffusion of medical advances, and that public health interventions such as motivational messaging around CRC screening and distribution of free non-invasive CRC screening methods may help with adherence in rural populations.[7]

A systematic review addressing CRC screening barriers in rural U.S. populations identified multiple factors including high cost, lack of a prevention attitude toward cancer, fear of finding cancer, embarrassment and perceived lack of privacy, distance to screening facility, and shortage of specialist as rural-specific barriers to CRC screening.[8] Additionally, gender specific barriers including the belief that CRC mainly affects men, and race/ethnicity specific barriers including poor provider communication, language barriers, and immigrant status, were found to contribute to lower rates of CRC screening in rural settings.[8] Family history of CRC, physician recommendation for screening, and health insurance were positively associated with CRC screening compliance.[8]

Underserved populations face barriers to CRC care at the policy, health system, provider, and individual levels.[9] These barriers must be addressed within the context of the resources and attitudes inherent to each specific setting; an urban location such as Mexico city has different needs than a rural area in the United States. Poor awareness and communication surrounding CRC, however, were repeatedly identified as barriers regardless of location, and health care professionals should strive to provide culturally appropriate education to their patients about CRC screening and treatment.

Screening and Surveillance Approaches

CRC screening tests allow for prevention and early detection of CRC and have been associated with improved survival, which is directly related to cancer stage at diagnosis.[10] However, due to limited access to screening modalities including colonoscopy, outcomes in low-resource settings are typically poor, and many patients present emergently with advanced, late-stage disease. Multiple complexities arise when CRC screening is considered from a global perspective. Due to the wide variability of health care environments, there is no "one size fits all" screening program. Moreover, the multiple testing options for CRC screening, including colonoscopy, sigmoidoscopy, capsule endoscopy (CE), CT colonography, guaiac-based fecal occult blood tests (gFOBT), fecal immunochemical testing (FIT), and stool DNA test (i.e., Cologuard), all differ in their cost, accessibility, and acceptability. Thus, to ensure equitable screening and adequate participation, the specific health care context must be considered. Even when screening programs are in place, inequalities in participation associated with socioeconomic status, education, age, gender, and ethnicity are frequently present.

There are two main CRC screening programs currently in place in multiple countries[11]:

1. *Population-based screening*: these programs target the entire population based on age. Invitations to screen are issued from the government or public sector. Typically, a primary screening modality is followed by secondary testing if positive. There are explicitly defined policies and systems in place to monitor follow-up of testing, outcomes, and quality control.
2. *Opportunistic screening*:
    - *Structured opportunistic screening*: typically supported by official policy with an aim of achieving widespread coverage of a target population. Screening depends on the individual or health care professional.
    - *Ad hoc opportunistic screening:* this type of screening depends on the individual or health care professional without an organized screening program in place.

According to a recent review by Young et al,[11] in 1999 there were only three established screening programs in place across the world: one population-based organized screening program (Japan) and two structured opportunistic screening programs (Germany and United States). Since 1999, there has been a rapid implementation and uptake of CRC screening globally. As of 2018, 29 population-based organized screening programs (19 European countries, Canada, Uruguay, Israel, United Arab Emirates, East and Southeast Asia, Australia, and New Zealand) and nine structured opportunistic screening programs (four European countries, United States, Colombia, Iran, Japan, and Malaysia) have been implemented.

Population-based screening may eliminate the barriers to access seen with opportunistic screening, however, this is not universally the case, emphasizing that multifactorial health care and cultural milieus typically require a more personalized approach. It is unlikely that asymptomatic population-based CRC screening will be feasible in many low- and middle-income countries in the near future, thus other paradigms must be explored in these settings. For example, the role of symptomatic-based surveillance models is being explored in Nigeria, where a recent multicenter prospective trial investigated a screening tool to predict increased risk of CRC in patients with rectal bleeding.[12] Risk stratification is particularly important in resource-limited regions where the incidence of CRC remains low but mortality is high, as in sub-Saharan Africa.[12] We discuss future directions and technological developments to facilitate risk stratification and screening in the global context at the end of this articles.

While there are no universal guidelines for CRC screening given the challenges previously discussed, the American Society of Clinical Oncology (ASCO) put forth resource-stratified guidelines for CRC screening in 2019. These guidelines are targeted toward individuals in resource-limited settings where CRC incidence is high, so cannot be widely applied, however, they provide a concrete framework to guide screening within this sub-population. The following recommendations have been adapted from the ASCO guidelines[13]:

Screening should take place from the age 50 to 75 years in asymptomatic, average-risk populations in high-incidence areas:

- Basic setting: gFOBT or FIT every 1 to 2 years if resources are available.
- Limited setting: gFOBT or FIT annually, or flexible sigmoidoscopy every 5 years, or flexible sigmoidoscopy every 10 years plus FIT every year.
- Enhanced setting: gFOBT or FIT annually, or flexible sigmoidoscopy every 5 years, or flexible sigmoidoscopy every 10 years plus FIT every year, or colonoscopy every 10 years.
- Maximal setting: gFOBT or FIT annually, or flexible sigmoidoscopy every 5 years, or flexible sigmoidoscopy every 10 years plus FIT every year, or colonoscopy every 10 years.

Reflex testing should typically be performed if patients have a positive result from CRC screening:

- Basic/limited: Patients should be referred for colonoscopy (preferred) or flexible sigmoidoscopy if available. If endoscopy is not available, clinicians should refer patients for double contrast barium enema. If a patient's barium enema is positive, refer for colonoscopy, if available.
- Enhanced/maximal: If patients have a positive result from a non-colonoscopy CRC screening test, colonoscopy should be performed.

Work-up and diagnosis for those with symptoms:

- Basic/limited: Physical exam with digital rectal examination, double contrast barium enema, or colonoscopy with biopsy if no contraindications are available. If contraindications to colonoscopy, then perform flexible sigmoidoscopy and barium enema.
- Enhanced/maximal: Colonoscopy with biopsy if no contraindications. If contraindications to colonoscopy, then perform flexible sigmoidoscopy with full visualization of the colon (barium enema or CT colonography). CT colonography if contraindications to both endoscopic options or double contrast enhanced barium enema.

Treatment Approaches and Outcomes

Surgical resection remains the pillar of treatment for colon and rectal cancer. With the rising rate of CRC in low- and middle-income countries, the need for access to surgeons is critical. Unfortunately, surgical care is often not available in resource-limited settings. Major challenges to the surgical management of CRC in resource limited settings include scarcity of surgeons, delays in diagnosis and treatment, limited surgical capacity of underserved hospitals, poor health literacy, and misconceptions surrounding surgery. Given these challenges, patients often either do not meet with a surgeon, or do so once their tumor has progressed to later stages, impacting prognosis and long-term survival. A study performed in Kenya demonstrated that curative surgery for patients with CRC in a rural hospital significantly improved survival at 1 and 5 years, identifying prompt surgical evaluation and treatment of CRC in resource-limited areas as a top health priority.[14]

1. Resource-stratified and evidence-based recommendations on treatment and follow-up of patients with ASCO.

Summarized below are recommendations by a multinational, multidisciplinary group of experts using evidence from existing guidelines and clinical experience[15]:

Colon cancer stages I-IIA, non-obstructing:

- Basic/limited: Open resection following standard oncologic principles (segmental colectomy with regional *en bloc* mesenteric lymphadenectomy).
- Enhanced/maximal: Laparoscopic or minimally invasive surgery (MIS) resection unless contraindicated (distended bowel, advanced disease, if cannot achieve R0 resection, or inability to tolerate pneumoperitoneum).

Colon cancer stages IIB-IIC, non-obstructing:

- Basic/limited: Open resection following standard oncologic principles.
  - If not possible, transfer to higher-level facility.
  - In emergency, limit to life-saving procedures.
- Enhanced/maximal: Laparoscopic or MIS resection. If not possible, then open resection.

Colon cancer stages IIB-IIC, obstructing:

- Basic/limited/enhanced/maximal: Resection following oncologic principles with or without fecal diversion.

Colon cancer diagnoses eligible for adjuvant treatment:

- Enhanced/maximal: May offer adjuvant chemotherapy (when indicated) in selective patients with high-risk stage II and stage III colon cancer.

Rectal cancer stage 1 (cT1N0):

- Basic/limited/enhanced: Total mesorectal excision (TME) principles.
- Maximal: Transanal excision in highly selective patients or MIS TME.

Rectal cancer stage 1 (cT2N0):

- Basic/limited/enhanced/maximal: TME principles (MIS approach when feasible, appropriate surgeon training and experience, and resources are available).

Rectal cancer stage IIA (cT3N0):

- Basic/limited: TME or transfer to higher capacity facility. Fecal diversion alone if obstructing tumor and TME cannot be performed.
- Enhanced/maximal: TME if R0 resection is expected based on preoperative magnetic resonance imaging or endorectal ultrasound. If preoperative imaging indicates 1 mm circumferential resection margin or less, advanced T3 substage or extramural vascular invasion, offers neoadjuvant therapy.
- Basic/limited/enhanced/maximal: May offer adjuvant therapy to high-risk stage II and stage III patients who did not receive neoadjuvant chemotherapy.

2. Minimally invasive options in low-resource settings.

Minimally invasive surgery has led to significant improvements in postoperative recovery and length of hospital stay. The uptake of MIS techniques, including laparoscopic and robotic surgery, has been limited in low- and middle-income countries, largely due to the cost associated with training and equipment.[16] Given the lack of trained personnel and necessary instruments, laparoscopy is not taught in many postgraduate surgical programs in low-resource countries, and often, laparoscopic training requires travel by either a visiting surgeon to underserved communities or by local surgeons to high-resource hospitals.[16] Virtual training via internet-based video platforms such as YouTube and Zoom is increasingly utilized to conduct remote laparoscopic surgical education. Innovations in creating inexpensive laparoscopic trainers out of locally available materials have also shown to be effective in bringing simulation experiences to these settings.[16] Robotic telesurgery, discussed in depth at the end of this chapter, is a cutting-edge technology that may also play a future role in providing MIS to low-resource settings.

Minimally Invasive Colorectal Surgery in the Global Context

The technical aspects of MIS present a steep learning curve, which is magnified by the added complexity of CRCs. The dissection required for adequate surgical margins and lymphadenectomy in both colon and rectal cancer operations is complex and calls for advanced MIS skills. For example, the pelvic dissection performed during TME necessitates familiarity with tissue planes as viewed from the laparoscope and experience with the haptics of MIS instruments for delicate tissue handling. Low colorectal anastomoses have a higher risk of anastomotic leak, and surgeons performing laparoscopic or robotic low-anterior resections must be adept at using the MIS-specific staplers to optimize distal rectal transection and potentially allow for an intracorporeal colorectal anastomosis that follows optimal surgical technique and principles. Moreover, the instrumentation is costly and may not be widely available in underserved areas.

We suggest that minimally invasive approaches can play an important role in CRC operations in low-resource settings where surgeons have received adequate laparoscopic training. Hand-assisted laparoscopic surgery or laparoscopic colon mobilization followed by resection and anastomosis through a lower midline or Pfannenstiel incision could potentially enhance post-operative recovery. This, in turn, could shorten hospital length of stay and expedite return to work, which ultimately may decrease financial burden to health care systems and patients.

3. Enhanced recovery after colon and rectal surgery in low-resource settings.

Enhanced recovery after surgery (ERAS) protocols and optimal care pathways have shown to reduce complications and length of hospital stay compared with conventional recovery strategies.[17] These pathways contain many recommendations throughout the perioperative course, including early mobilization and oral intake, goal-directed and early discontinuation of intravenous fluids, avoidance of urinary catheters and nasogastric tubes, and multimodal opioid-sparing analgesia, which have shown to be significant predictors of shorter hospital stay and reduction in the risks of postoperative ileus and surgical site infection.[18] In 2017, the American Society of Colon and Rectal Surgeons and Society of Gastrointestinal and Endoscopic Surgeons published clinical practice guidelines for enhanced recovery after colorectal surgery.[19] These guidelines made multiple recommendations from the preadmission phase through discharge, many of which are applicable to low-resource settings. In the preoperative time period, stoma education, marking, and counseling are inexpensive and critical components of elective colorectal surgery. Stoma teaching has been shown to improve patient quality of life, reduce length of hospital stay, overall costs, and prevent hospital readmissions due to dehydration.[19] In resource-limited areas where an ostomy therapist or nurse may not be available, the operating surgeon can provide ostomy education at the preoperative visit. Additionally, virtual platforms and online media options may play an increasing role in preoperative stoma education.

The use of bundles aimed at reducing infectious complications, that include preoperative mechanical bowel preparation with oral antibiotics and perioperative IV antibiotics limited to 24 hours postoperative, has been reported to significantly reduce surgical site infections and postoperative sepsis.[20] Preoperative bowel preparation is relatively cost-effective and accessible with the benefit of reducing postoperative infectious complications. Intra- and postoperative components of the guidelines for enhanced recovery after colorectal surgery including multimodal, opioid-sparing pain control, judicious use of intraoperative crystalloids, avoidance of abdominal drains and nasogastric tubes, early postoperative mobilization, early oral feeding, and early discontinuation of intravenous fluids and urinary catheters should be implemented in underserved settings as much as possible as these interventions are low-cost and have been shown to improve postoperative recovery.[19]

ERAS protocol implementation in rural hospitals has also been slower than in urban and suburban regions in the United States. A study by Smucker et al[21] examined pre- and post-ERAS recovery metrics after colon resection at a rural institution. The authors found that ERAS led to significant reductions in length of hospital stay and average cost reduction of $3,000 USD per patient. Despite rural-specific barriers to ERAS protocols such as lack of personnel, poor communication, resistance to change, patient comorbidities, and socioeconomic disadvantage, ERAS was feasible by overcoming these barriers, largely through patient and provider education.

4. Improving the quality of CRC resections by rural surgeons.

One of the major factors impacting CRC outcomes, in particular rectal cancer, is volume. High-volume centers have shown to decrease 30-day mortality and colostomy formation, increase adherence to treatment guidelines, improve the quality of surgical resection (higher lymph node yield and lower positive resection margin rate), and improve long-term overall survival.[22] Surgical volume in rural hospitals is significantly lower. In a recent study examining Medicare data in critical versus non-critical access hospitals, it was found that the annual surgical volume per hospital for colectomy was a median of eight cases versus 92, respectively.[23] This study demonstrated significantly improved in-hospital mortality, complication rates, and rate of hospital readmission for patients undergoing colectomy in critical access hospitals. However, these results are heavily confounded by baseline patient characteristics, with patients undergoing surgery in critical assess hospitals having significantly less comorbidities and undergoing less emergent operations.[23]

Geographical distance is one of the main barriers that rural providers face. To improve surgical education for rural general surgeons and to teach CRC-specific surgical principles, the geographical barrier needs to be overcome. In the era of emerging virtual learning platforms, virtual-online teaching and video recordings made available on YouTube should be optimized and encouraged. In addition, virtual and in-person workshops for teaching lymphadenectomy and total mesorectal excision should be offered to rural surgeons who have no effective means to refer patients with CRC to hospitals with specialized CRC care teams. More advanced workshops should also be conducted to teach principles of MIS colorectal resections and transanal local excision for low-risk early-stage rectal tumors. Additionally, training of rural pathologists in the assessment of colorectal specimens is critical to ensure accurate staging so that patients receive the appropriate postoperative therapies and surveillance.

Context-Appropriate Interventions and Solutions in Development

1. Robotic telesurgery could potentially breach the disparity gap by offering high quality MIS colorectal resections.

The emerging field of telesurgery, utilizing wireless networks and robotic surgical systems, allows surgeons to operate on patients in geographically distant locations. In 2001, the first transcontinental robot-assisted telesurgery was completed using the ZEUS system (Intuitive Surgical, Sunnyvale, California) by a surgeon in New York on a patient in Strasbourg, France.[24] A surgeon performed a successful cholecystectomy in 54 minutes and the patient recovered without complications. Robotic telesurgery has the potential to address some of the most prescient issues facing global surgery by eliminating geographical barriers to surgical care and alleviating the global shortage of surgeons in underserved areas. Telesurgery platforms can also be used as a tool for surgical collaboration and education between providers at distant locations, facilitating specialized training of surgeons across the globe. The educational benefits of robotic telesurgery are well demonstrated in the field of neurosurgery, where a virtual platform has allowed for multiple people to view a merged surgical field allowing for real-time surgical collaboration and training of remotely located surgeons.[25] A similar educational model applied to colorectal surgery would greatly benefit patients undergoing complex resections for CRC and inflammatory bowel disease. Furthermore, robotic surgery is particularly well suited for three-dimensional visualization of colorectal anatomy in small operative fields (i.e., pelvis), and enhanced patient recovery given its minimally invasive approach.

Since the 2001 landmark transcontinental operation, robotic telesurgery remains relatively limited in its use. The lack of widespread uptake is due to various factors, especially time latency and delay in transmission between surgeon location and the operating room. Latency times of 100 milliseconds or less are ideal, and up to 200 milliseconds are acceptable, while times greater than 200 milliseconds pose technical inaccuracies and safety hazards.[26] Increased latency times are largely due to network congestion and server overload.[27] For widespread telesurgery to be available, an efficient global network first needs to be in place and disparities in network availability must be solved. With ongoing advances in wireless communication technology, including the development of 5G and fiber-optic networks, the issue of latency time may be overcome. Another limiting factor is the financial investment required to implement telesurgery programs, which may be prohibitive for health care systems of less developed countries. Although the initial implementation cost is high, there is the potential for long-term economic advantage with telesurgery. For example, if patients with CRC are treated with best-practice surgery offered by telesurgery, they may suffer less complications from their disease and health care systems may ultimately incur less burden. Lastly, telesurgery presents novel billing, insurance, legal, and ethical issues that will need to be addressed in a global context as its use becomes more common.

Though robotic telesurgery is still in its early phases of development, this technology poses a platform for a feasible solution to bridge the need-gap that exists amongst surgical patients in underserved locations worldwide.

2. Use of artificial intelligence for identifying high-risk populations for screening purposes.

Due to the challenges that low-resource health care settings face in establishing comprehensive CRC screening programs, elaborating protocols to increase early detection of CRC remains a critical area for improvement. Employing artificial intelligence to augment currently available screening modalities may aid in identifying high-risk populations to streamline and create efficiency in CRC screening. Artificial intelligence also has the potential to improve the overall quality of CRC screening across multiple modalities, which would ultimately reduce CRC incidence and mortality not only in resource-limited areas but for all-comers.

Machine learning, specifically deep learning and neural network processing is being utilized to aid with image classification in CRC screening. These technologies, known as computer-aided diagnosis (CAD) systems, seek to enhance both polyp detection and classification during colonoscopy.[28] The adenoma detection rate (ADR), adenoma miss rate (AMR), and interval CRC development are important quality metrics of CRC screening. Higher ADR decreases the risk of post-colonoscopy interval CRC development, which has been shown to be as high as 8.6%.[28] AMR, ranging from 6 to 27%, may be due to inadequate bowel preparation, polyp size, withdrawal time, and operator experience. Use of automated polyp detection systems in real-time may significantly increase ADR during colonoscopy, which has been borne out in studies using CAD systems in conjunction with colonoscopy.[28,29] The use of CAD systems may help with diagnostic accuracy and ensure high quality screening in settings where there may not be an adequate number of experienced endoscopists to serve a population.

Given the scarcity of endoscopists in many underserved communities, the ability to perform colonoscopy as a population-based screening strategy may not be attainable and thus, other high-quality alternatives should be considered. CE is an attractive option in settings that lack traditional endoscopic resources. However, the accuracy of polyp detection by CE and subsequent colonoscopy remains uncertain. Additionally, the traditional manual process of identifying polyps on the images generated from CE is labor intensive and time consuming and does not address the need for polypectomy. Deep learning is being used to increase CE polyp matching capabilities and develop autonomous polyp detection algorithms. A recent prospective study in Denmark including 255 patients undergoing CE and subsequent colonoscopy investigated a matching algorithm that was able to detect polyps with 97% sensitivity and 93% specificity.[30] Automated CE screening technology could bridge the gap in worldwide screening due to scarcity of endoscopic equipment and trained practitioners in low-resource settings.

Virtual colonoscopy using CT colonography is another alternative to colonoscopy that will benefit from artificial intelligence, and machine learning algorithms are being explored to increase its ability to accurately detect precancerous lesions.[31]

One exciting application of artificial intelligence relevant to global surgery is its potential use in CRC risk-stratification of the general population. This is well illustrated in a retrospective study conducted on two national cohorts, one from Israel and the other from the United Kingdom, that used machine learning to develop and validate a model to identify patients at increased risk of CRC.[32] The model used individual trends in blood counts, age, and sex on sets of controls and cases collected 3 to 6 months prior to the diagnosis of CRC. A major strength of this model is that it is not based on presence of symptoms, which typically present at later stages of disease, but rather on laboratory value changes that precede symptom onset. They found their model to be significantly better at detecting CRC than age alone (basis for current screening guidelines), or iron-deficiency anemia guidelines, and it was able to identify earlier stage CRCs. When combined with gFOBT, its detection rate doubled. As the use of electronic medical records becomes more widespread across the world, using artificial intelligence predictive models in this manner may help identify at-risk individuals who can then be referred for further work-up. This will help appropriately allocate resources, such as endoscopic evaluation, to those who are most likely to benefit from it.

While artificial intelligence technology is still in its early phase for CRC screening, it has made its way into clinical practice for enhancing detection rates in mammography and CT scans for lung cancer. Artificial intelligence also has a vast potential to improve access to and quality of CRC screening among underserved populations, which would ultimately reduce the significant morbidity and mortality from this disease worldwide.

Conclusion

The global health inequities present in CRC incidence, mortality, and care exist within complex, multilayered societal frameworks. The disproportionate burden of CRC, with rising incidence and mortality in low- and middle-income countries, represents a disparity that can potentially be reduced through implementing widespread screening and best-practice treatments. The challenges to screening and surgical care of CRC in resource-limited settings are diverse, shaped by the cultural nuances and health care infrastructure of a specific community. Promisingly, there is a great deal of research being done to identify barriers and develop strategies to address them. Potential solutions in limited settings, such as utilizing targeted screening programs that identify at risk individuals to efficiently allocate endoscopic equipment and personnel, need to be coupled with culturally specific community level interventions that spread knowledge and debunk misconceptions surrounding CRC. While surgical guidelines for best-practice treatment ideally should be adopted, the global paucity of surgeons, lack of comprehensive CRC surgical training, and limited surgical equipment require surgical care to be tailored to the available resources. Finally, innovative technologies using artificial intelligence, machine learning, and remote telesurgery may play a role in bridging the gap in global CRC care in the future, and more research and development in this field are warranted.

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