Review

Challenges in Promoting Health Equity and Reducing Disparities in Access Across New and Established Technologies

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ABSTRACT

Medical innovations and novel technologies stand to improve the return on high levels of health spending in developed countries, particularly in cardiovascular care. However, cardiac innovations also disrupt the landscape of accessing care, potentially creating disparities in who has access to novel and extant technologies. These disparities might disproportionately harm vulnerable groups, including those whose nonmedical conditions—including social

Conclusion: Innovations in cardiac care can revolutionize delivery and quality, but care must be taken to ensure benefits are provided equitably at all stages of delivery. Recent developments may stand to continue or even exacerbate inequalities without careful planning. By acknowledging and actively addressing barriers to accessing novel technologies, the field of cardiac care can advance toward a more equitable future.

RÉSUMÉ

Les innovations médicales et les nouvelles technologies ont le potentiel d’améliorer le retour sur investissement des dépenses élevées en santé dans les pays développés, en particulier dans le domaine des soins cardiovasculaires. Cependant, les innovations cardiaques perturbent également le paysage de l’accès aux soins, créant potentiellement des disparités quant à qui a accès aux technologies nouvelles et existantes. Ces disparités pourraient nuire de manière

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determinants of health—inhibit timely access to diagnoses, referrals, and interventions. We first document the barriers to access novel and existing technologies in isolation, then proceed to document their interaction. Novel cardiac technologies might affect existing available services, and change the landscape of care for vulnerable patient groups who seek access to cardiology services. There is a clear need to identify and heed lessons learned from the dissemination of past innovations in the development, funding, and dissemination of future medical technologies to promote equitable access to cardiovascular care. We conclude by highlighting and synthesizing several policy implications from recent literature.

Improving the quality of medical treatments has immense economic and social value; indeed, medical innovation is hypothesized to be the most promising way to improve the return on high levels of health spending in developed countries.11–13 Approximately 70% of the improvement in life expectancy in developed countries between 1960 and 2000 can be attributed to innovations in antihypertensive medications, which dramatically reduced the burden of cardiovascular disease (CVD).14 Similar valuable developments have improved the quality of life for patients with aortic stenosis (AS), familial hypercholesterolemia, transthyretin cardiomyopathy, or heart failure (HF) with reduced ejection fraction.1,4–7

Medical innovations can also contribute to health inequities, which have affected marginalized individuals across socioeconomic status (SES), race, and ethnicity—among others—for more than 2 centuries.8,9 Successful innovations, particularly in cardiac care, hold tremendous potential to revolutionize medical practice and improve patient outcomes. However, the effect of such an innovation on cost- and access-based inequities largely depends on how it is implemented and made available to patients from diverse backgrounds.

Cardiac innovations are comprised of multiple developments: technological progress in device manufacturing, including pharmaceutical products; advancements in the availability and provision of medical interventions, such as surgical procedures or minimally invasive interventions; and innovations in infrastructure, including the use of electronic medical records (EMRs) or artificial intelligence (AI) to improve patient and provider experiences. As investments in CVD drugs plateau or even decline,10 research and development efforts in cardiovascular care have shifted toward the latter categories, which tend to be more cost-justifiable and amenable to leveraging community engagement to ensure, in theory, that innovations are distributed equitably across a population.11 We use the term “innovation” to encompass novel disruptions in the provision of care along any of these dimensions, and review historical innovations in their context (eg, statin use) as well as more recent developments (eg, HF therapy or minimally invasive interventions).

Health disparities typically exist even in cardiology at all levels of behaviour, diagnosis, treatments, and outcomes. Importantly, inequities are not driven by the costs of procedures alone, but are observed even for relatively inexpensive, extant technologies, such as among acute myocardial infarction (AMI) survivors beginning treatment with β-blockers and statins.12 Increasing reliance on high-cost medical interventions and the use of technology for digital solutions stands to leave groups of people with limited resources on the sidelines of accessing improvements in health.13

The development, dissemination, and adoption of innovations in cardiac care presents a challenge for reducing health-based inequities, in Canada and more broadly. Innovative practices might impose new constraints on achieving equitable access, not only through expensive technologies, but also through lapses in who obtains the relevant diagnoses and referrals necessary for access. In addition, innovations might interact with existing services, products, and technologies in ways that are less well understood, exacerbating existing inequities or generating new disparities among noninnovative adjacent services. Novel minimally invasive interventions such as transcatheter aortic valve implantation (TAVI) might reduce the availability of other percutaneous coronary interventions (PCIs), potentially exacerbating race- and income-based inequities in who has access to these adjacent services.8 In contexts such as the Canadian system where constrained physician capacity affects the returns to physician specialization, these spillover equity concerns are particularly relevant.

In this review article, we explore the tensions and challenges inherent in jointly pursuing 2 fundamental aims of the Canadian health care system: encouraging the dissemination of novel, welfare-improving innovation and ensuring equitable access to health care across a variety of dimensions. We first discuss innovations before engaging in a broader dialogue on their interactions with extant technologies and systems. We conclude with some policy recommendations and areas for future research.
The inequities we outline and policy recommendations we include result from synthesizing current literature on promoting health equity in cardiovascular care. Additionally, these results fit in the context of a broader discussion of equitable diffusion of technologies and innovation, including work that models the predicted dissemination of technologies and proposed policies to reduce inequities generated along those paths. Finally, our discussion is relevant to adjacent discussions of promoting health equity in more general settings, such as addressing problems of pharmacy deserts.

**Traditional Inequities in Accessing Novel Technologies**

Despite improvements in treatments and technologies to treat CVD, mortality rates exhibit disparities across race, ethnicity, sex, education, geographic location, and other social determinants of health (SDOH). These disparities persist, in part, because of unequal access to and take-up of historically innovative treatments. For example, some patient groups continue to incur significant financial burden when accessing cardiovascular care; this is true even in Canada, where lack of prescription medication insurance might result in financial burdens even for relatively low-cost drugs such as statins.

Cost need not be the only inhibitor to accessing care; women and nonwhite individuals are less likely to adhere to statin treatment, and black patients systematically have reduced access to intravenous tissue-type plasminogen activator for acute ischemic stroke. These issues underscore that disparities typically persist as the confluence of multiple gaps, spanning financial burden, provider bias, patient trust in the health care system and medications, and systemic discrimination, among others. Providers offer statins less frequently to women, who are also more likely to discontinue use of the medication than men.

In this section, we discuss the primary barriers to access to common and more recent cardiac innovations. Figure 1 illustrates key themes from this section, highlighting prominent barriers along the patient journey to treatment that might reduce or limit access. These barriers include gaps in patient knowledge and behaviour, diagnostic inequities, delays in accessing diagnoses and specialist referrals, cost-based inequities, and systemic discrimination.

**Diagnostic inequities: barriers to a timely diagnosis and referral**

An innovation’s effect on inequities for cardiac care largely depends on how it is made available to patients. Barriers to access might arise well before the point of an actual medical intervention, with some groups experiencing unmet health care needs as a result of lack of patient knowledge, incorrect or delayed diagnoses, or personal or social consequences to seeking treatment.

Between 20% and 40% of heart attacks occur in patients without a preexisting CVD diagnosis. Similarly, common but serious cardiological diagnoses are often delayed, including for congenital heart disease and AS; more rare diseases also suffer from this problem, including cardiomyopathy. Although these delays encompass multiple aspects—including limitations in the current ability to accurately predict cardiovascular events such as AMI—patients from marginalized groups might experience compounded delays because they either receive key screenings less frequently or are more likely to be lost to follow-up. Delayed or foregone diagnoses are more likely for individuals living further from medical facilities, including those in rural regions.

Disparities in screenings and referrals occur at multiple levels of cardiology care. Vulnerable groups are often less adequately screened for CVD risk factors. This is compounded by disparities in access to preventive health care services, leading to unequal opportunities for early intervention and management of risk factors.

These gaps persist and might even be compounded in more medically complex cases. Consider the case of severe AS, which requires multiple diagnostic exams performed by different physician specialties to correctly identify. Initial diagnosis typically requires patients to receive transthoracic echocardiography; however, patients from neighbourhoods with high ethnic concentrations are less likely to receive referrals out of primary care, potentially resulting in artificially lower estimated AS burdens. Even conditional on the use of transthoracic echocardiography, racialized groups remain significantly less likely to receive an AS diagnosis within 1 year. This might be, in part, because of the low prevalence of AS diagnoses by providers in the context of limited treatment options, particularly before the development of TAVI. Ultimately, these gaps in screening might lead to reductions in follow-up for black patients and gaps in surgical or percutaneous interventions.

These inequities in diagnosis, referral, and receipt of ongoing treatment pose unique challenges for the dissemination of innovative practices in cardiology. Novel technologies are useful only to the set of patients who arrive at the point of treatment; however, gaps in knowledge and behaviour among patients and general practitioners (GPs) inequitably limit this set of patients. For complex innovations such as minimally invasive interventions, patients must successfully acquire a referral from their GP, obtain the relevant diagnostic exams, and have the appropriate follow-up visits and consultations before arrival at the surgical suite.

Regional differences in how GPs opt for referrals further complicate these diagnostic inequities. In the case of AS, patients considered to be at high risk of surgical complications typically did not receive diagnostic referrals, a practice that changed with the arrival of lower-risk interventions such as TAVI. However, GPs exhibit evidence of information gaps, with many GPs not altering their diagnostic and referral behaviours until exposure to a TAVI within their patient pool; importantly, this differentially delays some patient groups from timely access to novel interventions. Patients without a GP in an urban area or academic teaching hospital, for example, might experience longer delays between symptom onset and diagnosis, and might experience worse complications and health outcomes as a result.

Rectifying these inequities requires increased emphasis on symptom detection by patients and inclusion of recommendations made by patients, for example through patient engagement groups or partnerships. Targeted information campaigns might help reach patients at risk of poor self-care or limited take-up of medical services, particularly for cardiac conditions. For example, women globally experience delays
in seeking care between time of onset and hospital admission for ST-segment elevation myocardial infarctions, resulting in an average of 16 minutes longer from symptom onset to interventional procedure. Women included in a focus group that explored this problem cited inadequate knowledge of cardiac symptoms and limited access to care—either general or specialized—as critical barriers to overcoming this gap.

Access inequities: barriers to receiving treatments

After diagnosis and referrals, patients continue to experience potentially differential levels of access to treatments. These inequities can arise from differences in medical complexity and urgency but might also be influenced by nonmedical factors including SDOH. The effect of inequities within cardiac care are further perpetuated by SDOH and resulting systemic and structural discrimination.

Financial barriers to access and adherence. When a novel cardiac technology has been created, its initial cost of development and production can be high, which might translate into an expensive treatment option for patients. In early stages, this can lead to significant cost-based inequities, leaving patients from lower-income communities or underserved populations excluded from either accessing the benefits of the innovation or adhering to existing treatment options. Over time, these discrepancies compound, resulting in a “trickle down” approach that leaves marginalized groups waiting for access to innovations that those with more resources enjoy, potentially widening—rather than closing—gaps in equity between and within richer and poorer countries.

These inequities are more commonly observed in countries or regions where patients bear responsibility for the cost of their care. However, even when the cost of a novel service is covered by a provincial or federal government, financial barriers might persist when a service is linked to expensive, noncovered medications. For example, adherence to angiotensin-converting enzyme inhibitors, β-blockers, or statin treatments after an AMI shows a clear income gradient in Canada, with men in the top income quintile having 37%, 50%, and 71% greater odds of initiating these prescriptions within 120 days of an AMI than men in the bottom income quintile. Although observational and subject to possible confounders (for example, with health education or literacy), this is in line with other evidence that reports patients reduce adherence to statin treatment after initiation because of cost concerns.

Generally, cost-based inequities decline over time as innovations become more widely adopted and integrated into mainstream health care practices. As demand increases, economies of scale might lead to cost reductions in manufacturing and distribution. Additionally, research and development investments for similar technologies might generate more affordable alternatives. Access to imaging services such as computed tomography, magnetic resonance imaging, ultrasound, and nuclear medicine imaging continues to improve in the United States and Canada, particularly as: (1) older-generation models become less expensive and more accessible after innovation; and (2) innovations make even new models less expensive, such as through open-source technologies. However, even increases in this form of access to older technologies occurs disproportionately quickly for high-income individuals.

Policy decisions and health care system reforms play a crucial role in addressing cost-based inequities for innovations. Government initiatives, private-public partnerships, or insurance coverage policies that support the adoption of innovative technologies can help make them more accessible to a broader range of patients. Moreover, if the innovation proves to be highly effective in improving patient outcomes and reducing overall health care costs, it might garner support from payers and health care providers, leading to broader coverage and lower out-of-pocket expenses for patients. This, in turn, can help mitigate inequities, making the innovation more accessible to a diverse patient population.

Figure 1. Inequities along the patient journey. GP, general practitioner.
Effect of SES on access. Closely related to financial inequalities, individuals from lower SES often lack equitable access to preventive cardiac care, essential medications, or timely interventions, leading to disproportionately higher rates of cardiac morbidity and mortality. Low SES is associated with reduced access to cardiac interventions such as coronary angiography or cardiac rehabilitation for AMI survivors. These associations persist among novel technologies; for example, patients with severe HF are differentially likely to receive left ventricular assist devices on the basis of socioeconomic, gender, racial, and geographic divisions. Access to advanced medical technologies can be difficult across health systems, with obstacles such as wait times in Canada or insurance coverage in the United States, exacerbating delays in services.

Access and adherence to innovative cardiac treatments depend on patient financial status as well as health literacy and engagement. Consider, for example, recent developments in the treatment of HF, which has undergone tremendous improvements in the quality of medical therapy affecting quality of life and survival. Despite this bulwark of clinical evidence, medication therapies such as sacubitril/valsartan remain significantly underutilized in some populations, with <70% of Canadian eligible patients beginning treatment and <30% of patients achieving the optimal dose. The reasons for this trend to manifest most prominently among low SES patients, who typically demonstrate reduced health literacy, face language barriers, and are more likely to live in remote or underserved areas with limited physician prescribing of novel medications arising from medical inertia.

Race- and gender-based gaps in access to care. Inequitable gaps in access to care exist across many dimensions, including divides that leave racialized patient groups with reduced access to care and poorer outcomes. Historically, some groups argued disparities could be primarily explained by differences in quality measures across hospitals, such as risk-adjusted differences in in-hospital mortality after AMI. More recently, evidence has suggested structural discrimination amplifies or drives these results, citing generally consistent hospital performance across risk-adjusted outcomes. Recent evidence used detailed EMR data to show that racial minorities in the United States experienced reduced rates of admission to the cardiology department of a hospital for HF, even after adjusting for hospital- and patient-level characteristics. Similar reports of systemic racism and discrimination have been identified in Canada as well, such as for First Nations patient groups. Identifying and recognizing structural discrimination in the health care system is vital to ensuring that innovations mitigate, rather than aggravate, existing gaps in access to high-quality care.

Effect of patient geography on access. Geography remains a critical barrier that affects equitable outcomes in Canada. To tackle geographic disparities, targeted efforts should be made to extend the reach of innovative cardiac care to remote and underserved regions. The implementation and expansion of telemedicine, particularly as a result of the COVID-19 pandemic, has increased access to high-quality health care facilities. This can involve establishing telemedicine networks, mobile health care units, and teleconsultation services. Collaborative partnerships between urban and rural health care facilities can also facilitate knowledge-sharing and enhance local capacities for diagnosing and managing cardiac conditions.

Regulation of specialized medicine in Canada can be reformed to improve access for patients who live in remote areas. For example, catheterization labs are provincially regulated in Canada, leaving continued discrepancies in access to care: patients in low SES areas (median family income: CAD$30,809) were found to be less likely to undergo cardiac catheterization than patients in high SES areas (median family income: $92,169).

Persistent Barriers to Access Among Extant Technologies

Even among cardiac technologies that can no longer meaningfully be termed innovations, disparities continue to persist that affect cost and geographical access. Persistent disparities among extant technologies reduce utilization and erode trust in the health care system for affected groups. In this section, we examine the effects of these disparities on health care outcomes and explore efforts to address these challenges, including social movements, service-related social innovations, social enterprises, and digital social innovations.

Assessing health disparities: The role of comprehensive data collection

Addressing persistent health disparities first requires collecting the appropriate data to assess their prevalence and associated burden. Comprehensive race- and equity-based data are currently lacking in Canada, which limits researcher ability to identify shortcomings and propose solutions; this is particularly relevant in the context of innovative treatments such as for patients with HF. By identifying areas of concern and tailoring interventions to meet the needs of diverse populations, health care agencies can take proactive steps toward eliminating health inequities and fostering an inclusive health care landscape.

Compiling comprehensive race- and equity-based health care data requires agencies to collaborate on the appropriate measures to be used in data collection. Data collection and reporting should be standardized and consistent across care providers and meaningful and acceptable for patients. As a baseline, data collection might follow standards that already exist on the collection of race-based and indigenous identification for health reporting in Canada. Expanding this approach can be used to understand disparities according to SES, income, education level, and employment, as well as patient language preferences and cultural backgrounds to improve culturally competent care and language-accessible services.

Innovations in data collection methods play a pivotal role in enhancing our understanding and addressing inequities in health care. Embracing technological advancements such as EMRs, mobile health applications, and AI-powered analytics enables more efficient and accurate data collection, analysis, and reporting. Further, gathering explicit data on patient feedback on their health care experiences and satisfaction uncovers disparities in quality of care, which enables health
care agencies to address patient concerns and enhance patient-provider relationships. By leveraging such technologies, health care agencies can collect and analyze comprehensive data to reveal patterns of inequity in access and outcomes, 86 and facilitate patient engagement and empowerment, ensuring that interventions are not only data-driven but also patient-centred. 86

Effects of disparities: Trust in the health care system

One significant consequence of disparities is the erosion of trust in the health care system among individuals from marginalized communities. When patients from underserved backgrounds consistently encounter obstacles in accessing essential cardiac technologies, they might develop feelings of alienation, skepticism, and disillusionment toward the health care system. Many indigenous individuals have a pronounced mistrust of and apprehension in accessing health services, which ultimately affects their health and well-being. 87 The perception of an inequitable health care landscape can undermine patients’ confidence in physicians or treatments and might deter them from seeking medical care altogether. 88 This loss of trust can impede effective patient-provider communication, hinder treatment adherence, and result in delayed or inadequate health care-seeking behaviour.

This reduced uptake of health care services among marginalized groups perpetuates health disparities. When individuals face barriers in accessing established cardiac technologies, they might forego routine screenings, preventive care, or early intervention, increasing the risk of disease progression and adverse health events. 89 For instance, marginalized communities might experience higher rates of uncontrolled hypertension, delayed diagnosis of cardiac conditions, or suboptimal management of chronic diseases because of limited access to monitoring and therapeutic technologies.

The cumulative effect of disparities in accessing cardiac technologies on health outcomes is far-reaching. Individuals who face barriers to essential technologies might experience delayed diagnosis, suboptimal treatment, and compromised disease management, all of which contribute to worse health outcomes. Existing data suggest that the indigenous population in Canada overall have poorer access and outcomes compared with those of nonindigenous peoples in Canada. 62 Health disparities manifest in higher rates of preventable hospitalizations, increased disease burden, and elevated mortality rates within marginalized populations. The perpetuation of these disparities reinforces a vicious cycle, because suboptimal health outcomes can further exacerbate mistrust in the health care system, leading to continued disparities in health care utilization and health status.

Attempts to address disparities

Attempts to address the disparities in accessing cardiac technologies and promote health equity have given rise to various social innovations. 86 These social innovations encompass a diverse range of strategies, including social movements, service-related social innovations, social enterprises, and digital social innovations. Although inter-related, these developments are distinct in their scope and application.

Social movements are organized, sustained campaigns aimed at goals changing (or preventing change to) a society’s structures or values. 80 These are regular sources of motivation for population health and can play a pivotal role in advocating for policy changes in cardiac care, raising awareness about health disparities, and mobilizing communities to demand equitable access to scarce health care resources. 79 Although the long arc of a social movement’s goals is different than the sense of urgency and focus on short-term goals induced by traditional medical training, 77 engagement of clinical professionals with social movements can generate meaningful improvements in health by making salient features such as SDOH in clinical practice.

Many social movements globally attempt to engage patients—particularly in underserved areas—regarding health behaviours to mitigate CVD risk factors. These include the P2 Initiative from the Libin Cardiovascular Institute, 92 America Walks, 93 or the Narayana Hrudayalaya Heart Hospital, which mobilizes volunteers to help patients in rural India obtain appropriate diagnoses and knowledge about their treatment options. 94 In each of these movements, social groups meet physicians and patients in their contexts to bridge gaps that generate diagnostic and access-based inequities.

Engagement with social movements might lead to the creation of service-related social innovations, novel approaches to health care delivery that prioritize inclusivity and equity. These innovations, meant to promote new approaches to challenging aspects of health care delivery, are vague and often difficult to operationalize. 95 Examples of service-related social innovations include collaborative care models, community-based clinics, and outreach programs that specifically target underserved populations, providing tailored and accessible cardiac care services. 96 It is important that these social innovations be co-created with its patients to ensure sustainable outcomes that are relevant for the society or needs of specific groups. 95

A particularly relevant example of social innovations are digital social innovations including telemedicine and digital health platforms, which leverage technology to bridge gaps in health care access for individuals with limited access to health care facilities. By enabling remote consultation, monitoring, and disease management for cardiac patients regardless of location, digital innovations expand the reach of health care services and facilitate equitable access to cardiac technologies and care. 97 However, even digital innovations might generate new barriers to cardiac interventions if access to technology is lacking, such as in areas with poor internet access or insufficient funds to purchase or have access to required hardware (eg laptops, tablets, or smartphones).

Finally, social enterprises represent another avenue of social innovation in promoting health equity. 98 These enterprises include “sustainable ventures that combine business principles with a passion for social impact” 99 and might generate social innovations to offer sustainable solutions to address health care disparities. Social enterprises such as the Cardiovascular Network of Canada and others are key in integrating patient voices into cardiac research and service delivery; other enterprises aim to provide affordable cardiac medical devices, or engage stakeholders in research and development. 98, 100
**Equity Concerns Arising From the Interaction of Novel and Extant Technologies**

When considering the tradeoffs in promoting equitable access to care and the development and dissemination of cardiac innovation, a critical—and often overlooked—consideration is how novel technologies disrupt the landscape of accessing other, older adjacent technologies. Innovation does not occur in a vacuum, and physicians, hospitals, and other health care professionals are often time-, knowledge-, and capacity-constrained in which practices they can safely and effectively administer.

We consider these interactions in this section, using the case of TAVI’s adoption to treat aortic stenosis (AS) as a case study. The example of TAVI’s adoption highlights the short-term effects associated with disruption in cardiac care markets. In particular, TAVI’s adoption affected equitable access to aortic valve replacement procedures in positive ways for some groups, while potentially negatively affecting access to other interventional cardiology services.

TAVI is a novel percutaneous intervention to treat moderate to severe AS that has disrupted the market for AS treatments. The minimally-invasive nature of TAVI makes it suitable for patients at intermediate or high risk for mortality from traditional open surgical methods; conditional on risk, TAVI is cost-effective relative to open surgical methods. Over time, TAVI’s use has expanded to include lower-risk patients, becoming the leading intervention to treat AS in 2017. However, important access gaps persist, with fewer than half of patients who need a valve replacement receiving intervention in the United States, a figure likely mirrored in Canada.

First, TAVI’s rapid adoption might have reduced disparities in access within the specific market of valve replacements to treating AS. Before TAVI’s adoption, geographic, socioeconomic, and racial and ethnic divisions contributed to inequitable access to surgery, a fact that was mirrored in the early days of TAVI. This resulted in geographic variation in TAVI take-up within and across provinces and poorer TAVI outcomes for individuals in the most socially deprived communities. However, these disparities can be primarily attributed to “upstream” ethnic gradients affecting diagnostic inequities (this is addressed in the section, Diagnostic Inequities: Barriers to a Timely Diagnosis and Referral). When differences in AS burden are taken into account, disparities in TAVI referral rates across groups are strongly reduced. In addition, TAVI’s adoption is associated with a reduction in racial gaps in access to valve replacements overall as TAVI became more ubiquitous.

Although TAVI might have increased general access to valve replacement interventions, there is also evidence that TAVI’s adoption generated new inequities in accessing adjacent services. Specifically, TAVI’s adoption disrupted the practice styles of interventional cardiologists, who previously did not perform open surgery for valve replacement. When TAVI became widespread enough to consume the interventional cardiologists’ time, its adoption limited the availability of other PCIs. Hoagland reported that this competition resulted in overall decreases in the volume of interventions in a local market, hampering patient access to older percutaneous procedures such as angioplasties and resulting in fewer patients receiving any specialist treatment altogether. This is consistent with previous findings that showed rapid expansion of TAVI to even previously minoritized patient populations, including in the United States and Canada. Such rapid expansions might limit surgical capacity and result in crowding-out of other, older technologies including PCIs.

Hoagland used data from Medicare patients in the United States to estimate the effects of TAVI adoption on other interventional cardiology procedures at the local market level (measured as commuting zones in the United States, the equivalent to metropolitan areas in Canada). The author identified the causal effect of TAVI adoption on local market outcomes using a dynamic differences-in-differences approach, leveraging short-run variation in the timing of TAVI adoption across markets. At the time of TAVI adoption, the total number of interventional cardiology procedures provided in these markets decreased post adoption (Fig. 2A); total provision declined by nearly 40% in 3 years. Perhaps most importantly, these effects were strongest in racialized and minoritized communities, suggesting inequitable loss of access to specialty medicine after a disruptive innovation. When the effects across local markets are stratified according to their degree of racial marginalization, racialized communities experienced declines in availability of interventions approximately double that of less minoritized commuting zones (Fig. 2B). This is consistent with other literature that shows that although TAVI improved accessibility across racial subgroups in the United States and Canada, it did so at uneven rates, potentially exacerbating inequitable access to valve replacements.

Although no research has been done to explore the adjacent effects of TAVI’s adoption in the Canadian context, similar mechanisms and challenges are likely to be at play in the generation of novel adjacent inequities. Importantly, capacity constraints that generate tradeoffs in how surgeons and other health care professionals utilize their time are perhaps stronger in Canada than in the United States because of limits to Canadian medical infrastructure and limited volumes of new medical trainees in any year. Furthermore, there is Canadian-specific evidence to show that rapid adoption of cardiac interventions such as bypass surgery, echocardiography, stress testing, and PCIs crowded out access to other cardiac procedures, reflecting a trend where emerging technologies affect the overall availability and distribution of services.

Although the results of Hoagland have yet to be replicated in other markets, countries, and contexts, the risks of innovations that exacerbate access barriers to other adjacent technologies are supported by additional research in other settings. A key example is the integration of AI into clinical practices such as cardiac imaging, ostensibly to improve accuracy and precision. Although such integration might improve the detection of clinical risk factors, minoritized patients might suffer if AI models make patient race more salient, potentially exacerbating racial inequities that already exist in practice. For example, Gichoya et al. discuss scenarios in which AI-enhanced models make medical decisions based, in part, on their detection of patient race; because these decisions occur within a black box, they might not be directly observable to clinicians or hospital staff. If the model then generates race-specific errors in medical decision-making, without access to racial demographic characteristics
specialists might propagate these errors. Similarly, AI-enhanced imaging models might displace access to older imaging technology, entrenching disparities in access, such as in remote or underserved regions as a result of increased reliance on urban, AI-enhanced models.126

As a final example, consider the case of innovative practices in cardiac imaging. Recent research suggested that emergence of advanced imaging services for HF patients—including coronary computed tomography angiography, cardiac magnetic resonance imaging, and cardiac positron emission tomography—led to reductions in the availability of older services such as transthoracic echocardiography that were greater than total take-up of new services (eSupplemental Figure 1).127 This article did not report on equity outcomes directly, and considered that some of the reduction might be confounded by a new accreditation program for echocardiography; however, the results are suggestive that innovation affected overall service availability.

Taken together with this evidence, the TAVI case study and other, ongoing clinical research highlights that an innovation might have important effects on equitable access to care within a disease category and across adjacent specialties, diagnoses, and treatments. Importantly, these effects might be distinct or operate in conflicting directions, as is potentially manifest in the case of TAVI. The mechanisms governing these interactions are complex and case-specific but must be considered holistically regarding the equitable diffusion of innovations.

**Policy Implications and Directions for Future Research**

Ensuring the equitable diffusion of medical innovations, particularly in cardiovascular care, requires balancing a complex set of case-specific circumstances that differ across technologies, diagnoses, and health care organizations, among others. Potential solutions to overcome inequitable access to one technology might have spillover consequences that affect equitable access to others, further underscoring the need for case-specific solutions.

In this section, therefore, we outline general principles that have been studied and discussed in recent literature, with the potential to reduce or eliminate structural barriers to access at each stage of the patient journey (Fig. 1). These principles are summarized in Table 1 and include proposed policies that improve access to primary care, referrals to specialists, and ultimately, access to novel medical technologies. The principles may be applied across different categories of innovations, ranging from medical practices and new drugs to novel technological solutions in health care administration.

First, policy solutions should target previously understudied gaps in access to primary care arising from knowledge barriers and resulting in diagnostic inequities.40 Patient education, specifically for marginalized groups, should be expanded beyond simple attempts to engage patients in modifying risk factors, and must include information about how and when to seek care. Similarly, eliminating the diagnostic burden borne by these communities requires addressing prolonged wait times and physician shortages. In these cases, digital innovations might be helpful; by using data-driven approaches and evidence-based practices, health care providers can identify bottlenecks and implement strategies to expedite diagnostic assessments, treatment planning, and intervention delivery. Furthermore, digital innovations such as innovative scheduling systems can help ensure patients receive timely access to life-saving procedures and therapies.

Second, solutions must address inequitable delays in upstream progress for patients, including disproportionately long wait times before seeing a specialist. Delays in accessing time-sensitive specialty care further compound public and private costs of cardiac interventions, because they increase patient risk for complications, readmissions, and mortality.128 In this case, comprehensive data collection is key to identify pathways that facilitate access for some groups while leaving others behind. In tandem with this identification, public policy shaping regulation of health care facilities (eg, catheterization
Finally, policies must address systemic racism and discrimination within the health care system in targeted, case-specific ways. Health care institutions should actively work to eliminate bias in treatment decision-making, recruit diverse health care professionals, and provide cultural competency training to enhance patient-provider communication and understanding. Additionally, empowering patients from marginalized communities to become advocates for their own health and offering tailored support services can help dismantle systemic barriers and ensure equitable care delivery. This empowerment complements the returns on reducing diagnostic inequities discussed previously.

The general solutions that have been outlined will require different modifications according to the type of technology at hand. For example, incorporating technological innovations such as telemedicine into cardiac care requires a careful balance between innovation and equity. To bridge the digital divide, efforts should be made to expand internet access and technology literacy in underserved populations and prioritize patient education so that telemedicine can be leveraged effectively. However, procedural innovations such as minimally invasive surgical techniques and implantable devices might initially be limited to specialized centres with extensive resources, contributing to cost-based inequities. Ensuring

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### Table 1. Proposed policy solutions to promote equitable innovation dissemination

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<th>Policy recommendation</th>
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<td><strong>Knowledge barriers</strong></td>
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| Legislation against cardiac health disparities | - Strengthen legislation explicitly addressing disparities in cardiac care  
- Incorporate protections against discrimination on “social conditions”—including race, ethnicity, or socioeconomic status—which do not currently exist in many provinces under the Canadian Human Rights Act29  
- Clarify provision of public services to groups such as First Nations and Inuit peoples in legislation30 |
| Patient navigation services | - Assist patients from underserved backgrounds in accessing treatments, understanding treatment options, and managing follow-up care in cardiac care facilities |
| Targeted information campaigns | - Expand patient education beyond risk factor modification, including information on accessing medical care |
| Diagnostic inequities | - Identify patient groups at risk of reduced access to cardiac care |
| Telecardiology expansion | - Use targeted information campaigns to improve knowledge about care options for these groups |
| **Equity in preventive cardiac care** | |
| Equity in preventive cardiac care | - Promote equitable access to preventive cardiac care through increased access and financial support |
| Physician continuing medical education | - Develop interventions in collaboration with affected patient groups |
| **Delays** | |
| Health equity impact assessments | - Promote awareness of innovations in cardiac care, particularly for general physicians treating underserved populations (eg, through financial incentives or scholarships) |
| Community outreach and education | |
| Universal access to cardiac procedures | - Incorporate health equity impact assessments into approval processes for new cardiac technologies  
- Ensure that manufacturers and developers consider the potential effect of innovation on health disparities and patient experiences |
| Cost-based inequities | - Redistribute geographic availability of essential cardiac procedures to improve equitable access |
| Equity in cardiac medications | - Address cost barriers to life-saving cardiac medications through subsidies and/or generic drug availability  
- Improve affordability of cardiac devices, for example through public subsidies for specific patient groups |
| Affordable cardiac devices | - Encourage development of affordable medical solutions, informed by consultations with disadvantaged patient communities |
| Partnerships for innovative treatment | - Use public authority and purchasing power to more effectively allocate resources to disadvantaged communities |
| Social enterprises | |
| Government negotiation and subsidies | - Design incentives for providers to refer eligible patients to these programs regardless of background |
| **Systemic discrimination** | |
| Inclusive clinical trials | - Ensure diverse clinical trial participation to ensure effectiveness across various populations  
- Include equity-based frameworks such as PROGRESS-Plus (https://methods.cochrane.org/equity/projects/evidence-equity/progress-plus) consistently in clinical trials |
| Cardiac rehabilitation programs | - Improve equitable access to cardiac rehabilitation programs for disadvantaged groups |
| Data collection and reporting | - Design incentives for providers to refer eligible patients to these programs regardless of background |
| Cultural competency training | - Mandate comprehensive patient demographic data collection in cardiac care  
- Collect data in consistent ways and in collaboration with patient groups  
- Use patient-reported outcomes data to improve equitable access and outcomes |
| **Address cost barriers to life-saving cardiac medications through subsidies and/or generic drug availability** | |
| **Universal access to cardiac procedures** | |
| Cost-based inequities | - Encourage development of affordable medical solutions, informed by consultations with disadvantaged patient communities |
| **Government negotiation and subsidies** | |
| **Mandate comprehensive patient demographic data collection in cardiac care** | |
| **Collect data in consistent ways and in collaboration with patient groups** | |
| **Use patient-reported outcomes data to improve equitable access and outcomes** | |
| **Promote community-based cardiac education programs—particularly informed by affected patient experiences—to raise awareness about cardiac health** | |
| **Use public authority and purchasing power to more effectively allocate resources to disadvantaged communities** | |
broaden accessibility of procedural innovations necessitates careful consideration of reimbursement policies and resource allocation to democratize access and extend the benefits to all patients, irrespective of their financial circumstances or geographical location.

Another critical example is the integration of AI technologies for personalized cardiac care. AI-driven diagnostic algorithms, risk stratification models, and treatment optimization tools can enable more precise and efficient health care delivery. The successful implementation of AI in cardiac care also demands attention to potential biases in data collection and model development. Without careful calibration, AI applications might inadvertently perpetuate existing disparities or create new ones. To maximize the benefits of AI while safeguarding against potential inequities, rigorous validation, transparency, and diversity in data sources are imperative.

By embracing a nuanced and inclusive approach to adopting and implementing diverse technology types, the field of cardiac care can strive toward enhancing equitable access to novel innovations for all patients.

Conclusion

Cardiac innovations have the potential to revolutionize health care delivery and quality of life, but care must be taken to ensure that these benefits are provided equitably to a population. Existing medical technologies suffer from systemic biases, access issues, and financial barriers that limit their use for many subgroups of the population; recent developments in these technologies in some cases stand to continue or even exacerbate these limitations. In fact, cardiac innovations might even result in spillover effects that generate novel inequities in accessing existing, more standard, services.

With an eye toward promoting equitable diffusion of innovation, public policy and partnerships can be forged to minimize and reverse these disparities. By acknowledging and actively addressing the barriers to accessing novel technologies, the field of cardiac care can advance toward a more equitable future. In synergy with efforts to reduce cost-based inequities, embracing inclusive policies, technological innovation, and cultural competence will collectively drive the journey toward equitable access to cutting-edge cardiac technologies, ultimately benefiting all patients regardless of background.

Ethics Statement

The authors confirm that an ethical statement is not applicable to this article. This is a retrospective review article using nonhuman data.

Patient Consent

The authors confirm that patient consent is not applicable to this article. This is a review article without any original data analysis; therefore the research ethics board did not require consent from any patients.

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References


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56. Moledina A, Tang KL. Socioeconomic status, mortality, and access to cardiac services after acute myocardial infarction in Canada: a systematic review and meta-analysis. CJ C2021;3:950-64.


100. CANet: Cardiovascular Network of Canada Enhances its Digital Health


119. Miranda RN, Qiu F, Manoragavan R, et al. Drivers and outcomes of variation in surgical versus transcatheter aortic valve replacement in


