



Disparities in Cardio-oncology: Effects On Outcomes and Opportunities for Improvement

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Abstract

Purpose of Review The purpose of this article is to provide a comprehensive review of available data on health disparities and the interconnected social determinants of health (SDOH) in cardio-oncology. We identify the gaps in the literature and suggest areas for future research. In addition, we propose strategies to address these disparities at various levels.

Recent Findings There has been increasing recognition of health disparities and the role of SDOH on an individual's access to health care, quality of care, and outcomes of the illness. There is growing evidence of sex and race-based differences in cancer therapy-related cardiotoxicity. Recent studies have shown how access and quality of health care are affected by financial stability and rurality. Our recent study utilizing the social vulnerability index (SVI) and county-level patient data found graded increase in county-level cardio-oncology mortality with greater social vulnerability. The incremental impact of social vulnerability was higher for cardio-oncology mortality than for mortality related to either cancer or CVD alone. The mortality rates in these patients were higher in rural areas compared to urban areas regardless of social vulnerability. Additionally, for those within the counties within highest social vulnerability, Black individuals had significantly higher cardio-oncology mortality compared with White individuals.

Summary Disparities in the cardio-oncology population are deep-rooted and widespread, leading to poor quality of life and increased mortality. It is crucial to integrate SDOH, not only in clinical care delivery but also in future research, and registry data to improve our understanding and the outcomes in our unique subset of cardio-oncology patients.

Keywords Disparities · Cardiovascular disease · Cancer · Cardio-oncology · Social determinants of health

Introduction

Cancer mortality rates have been consistently down-trending since the 1990s, with a 31% relative reduction from 1991 to 2018 [1]. However, cancer remains one of the leading causes of mortality worldwide. It is the second most common cause

of death in the USA. According to the American Cancer Society estimates, approximately 5200 new cancer cases are diagnosed every day in 2021, and around 1600 daily deaths are linked to cancer [1, 2]. The decline in death rate is attributed to better screening, novel treatment therapies, and decreased smoking. On the other side, cardiovascular disease (CVD) not only claims most lives in the USA and globally, but it is also the primary cause of death in cancer patients and survivors [2, 3]. According to a study of 7.5 million cancer patients, 5% percent of patients died of CVD [3]. Cancer and CVD often co-exist, share multiple risk factors, and contribute significantly to population morbidity and mortality. As a result, the field of cardio-oncology has evolved to care for cancer patients at the interface of cancer and CVD. While there have been numerous advances in cardio-oncology, the disparities of health care in this patient population are relatively under-addressed.

This article provides a comprehensive review of the available data on disparities in cardio-oncology and the role of

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social determinants; we also identify the gaps in the literature and areas of research and suggest strategies to reduce inequities in this unique subset of patients (Fig. 1).

Social Determinants of Health and Disparities: Distinct but Inter-connected

Disparities in healthcare are interconnected with social determinants of health (SDOH). SDOH are the circumstances in which people are born, grow, live, work, and age [4]. The Center of Disease Control divides the SDOH into five sections: 1) Economic Stability, 2) Education access and quality, 3) Healthcare access and quality, 4) Neighborhood and built environment, 5) Social and community context [4]. The World Health Organization released the landmark report in 2008, which provided concrete evidence of the impact of SDOH on health status and laid out approaches to tackle

the inequitable distribution of healthcare resources, living conditions, and gender disparities [5].

Several studies on patients with CVD and heart failure (HF) have demonstrated the adverse impact of healthcare disparities on outcomes. As a result, both the American College of Cardiology (ACC) and American Heart Association (AHA) have issued statements addressing the SDOH in CVD and HF providing interventions to address socio-economic profile, healthcare coverage, health literacy, and ethnic and racial disparities. [6, 7]

Similar to cardiology, the role of SDOH in the risks, rates, and survival of multiple cancers is increasingly emphasized, and efforts are directed to address them [8, 9]. American Cancer Society has recently released a framework of practice, research, and policy to better recognize and address the SDOH in cancer [8]. The Society aims for a 40% reduction in cancer mortality by 2035 (from 26% in 2015) and recognizes that interventional measures would have to be applied equitably [10].

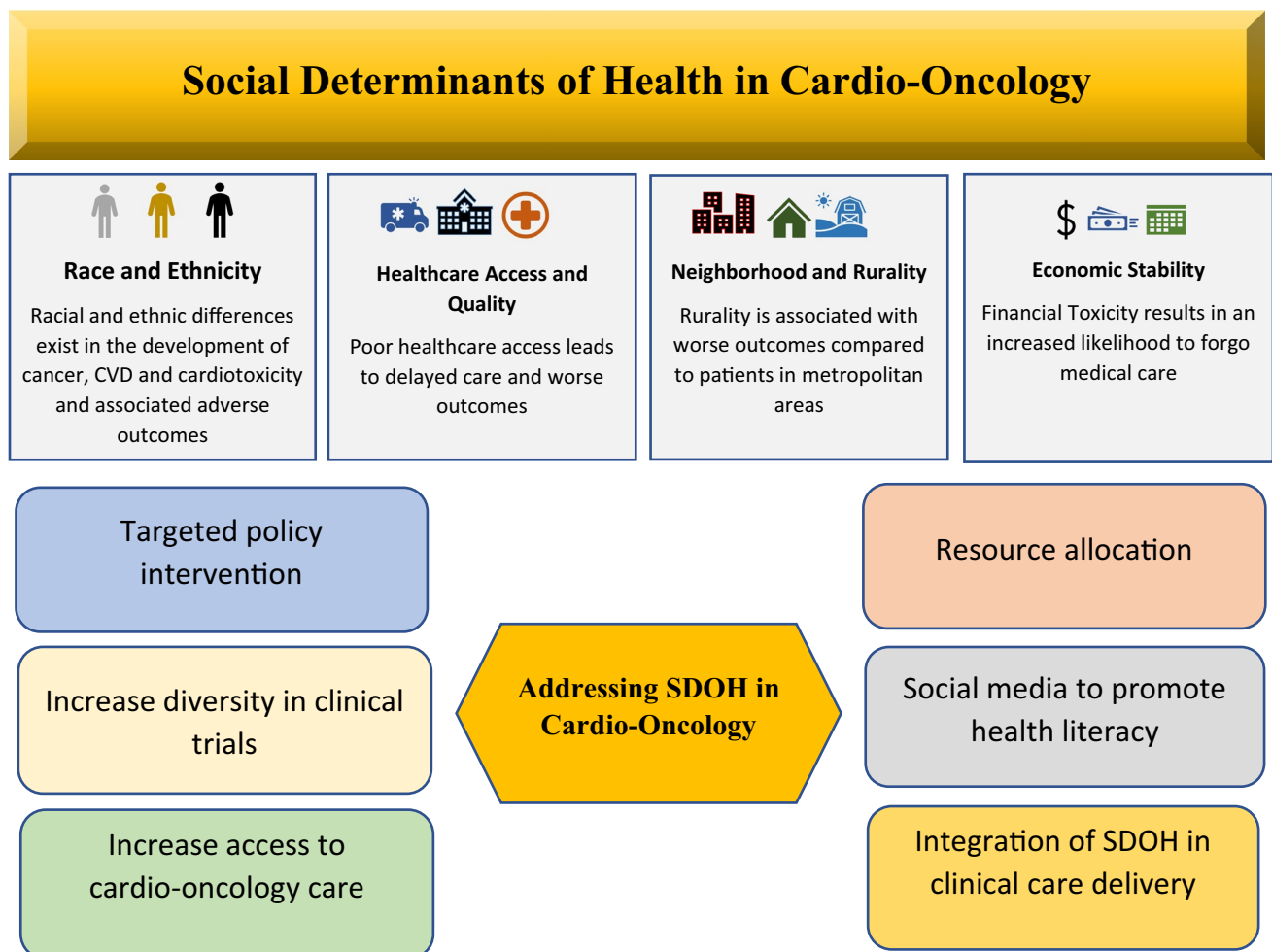


Fig. 1 Contributory factors for disparities in cardio-oncology and the suggested interventions to address these disparities

Emerging evidence suggests that, similar to the cardiology and oncology patient population, SDOH play a vital role in the health of cardio-oncology patients. Our (unpublished) cross-sectional study using the CDC Wide-Ranging Online Data for Epidemiologic Research (WONDER) database and county-level social vulnerability index (SVI) data demonstrates that age-adjusted mortality rate (AAMR) for concomitant CVD and cancer was higher across age, sex, race, and urbanization, in counties with greater social vulnerability. Similarly, AAMRs for CVD and cancer were significantly greater in the highest socially vulnerable counties. However, the proportional increase in comorbid cancer and CVD-related mortality between the highest and lowest SVI counties was more significant than that observed for either CVD or cancer-associated mortality alone.

Disparities in Cardio-oncology

Racial and Ethnic Disparities

Race and ethnicity play a crucial role in cancer incidence, rate, and outcomes in the USA [11]. African-American (AA) patients have the highest mortality rates from all cancers combined compared to all other races and ethnicities in the USA [12]. AA men and women, American Indian men & women, and Asian/Pacific Islanders men have lower five-year survival rates compared to their non-Hispanic White counterparts [12]. Cancer is the leading cause of death in Hispanics/Latinos. Compared to non-Hispanic Whites, Hispanics are less likely to be diagnosed with cancer at an early stage [13].

Similar to cancer incidence and mortality, there are disparities in the development of cardiotoxicity among different races. AAs had a three times higher risk of developing cardiotoxicity with doxorubicin compared to non-AA patients in a study of 100 patients [14]. Childhood cancer survivors of African ancestry receiving cardiotoxic therapies had an increased risk of cardiomyopathy than those with European ancestry [15]. In a small study, AA patients had a higher risk of developing cardiotoxicity with trastuzumab than White patients and received incomplete cancer therapy as a consequence [16]. Another larger study on trastuzumab-related cardiotoxicity showed that AA women had a higher prevalence of risk factors for CVD. The risk of cardiotoxicity was significantly higher in AA women compared to White women even after controlling for cardiovascular risk factors [17]. Our study found that Asian & Pacific Islanders and Hispanics had the highest relative increase in cardio-oncology mortality between the 4th and 1st SVI quartiles. Additionally, AA individuals had the highest CVD, cancer, and comorbid cancer and CVD-related mortality. This was

observed even within the most socially vulnerable counties when compared to White individuals [18••].

Racial minorities are also underrepresented in clinical trials. In one trial assessing dexrazoxane's cardioprotective effects in pediatric sarcoma patients receiving doxorubicin, the participation of AAs was 11% in the control arm and 13% in the intervention arm, Hispanics were 5.6% and 13%, and Asians were 5.6% and 0%, respectively [19]. In another trial of dexrazoxane in anthracycline toxicity, 6% of the control group and 8% of the intervention group were AAs, with other minority races comprising 1% and 2% of the control and dexrazoxane groups, respectively [20]. Similarly, in more contemporary imaging-based guidance for cardioprotective therapy initiation clinical trial—Strain Surveillance of Chemotherapy for Improving Cardiovascular Outcomes [SUCCOUR], only 2% of AAs participated [21]. Time and again, historical and contemporary research studies demonstrate that underprivileged race and ethnic groups are underrepresented, highlighting the need to achieve equity in trial participation.

Sex-based Disparities

There are known sex-based disparities in both cancer and CVD. Women have been traditionally under-represented in clinical trials. There are differences in the representation of women between trials that reported statistically significant findings versus those that did not, with fewer women in significant trials [22]. The importance of improving representation and demographic reporting has been echoed by national organizations, yet these disparities persist. Women have been shown to receive less intense CVD medical therapy as well as less lifestyle counseling compared to men [23]. Similar disparities exist in cardio-oncology. Although male sex is thought to be an important risk factor in the development of cardiomyopathy, secondary to higher apoptosis-related protein expression [24], in a study of patients treated with anthracyclines, women were at higher risk of cardiac dysfunction than men [25]. A systematic review assessing cardiovascular mortality following radiation therapy for Hodgkin's lymphoma found that cardiovascular events and mortality were four times higher in women compared to men [26].

Disparities in Healthcare Access and Quality

Cancer survivors have been shown to have difficulty accessing healthcare. In a study of 30,364 cancer survivors from the National Health Interview Survey (NHIS), cancer survivors were more likely to report delayed care, forgo medical care, and be unable to afford medications when compared to

control respondents [27]. Healthcare access disparities were recognized and explained for minorities, including Blacks, Hispanics, Asians, and Native Americans, compared to the White population in the landmark report of the Secretary's task force on "Black and Minority Health" in 1985. Cancer and CVD were reported as the top two of the six causes of excess mortality in the Black population compared to the White [28]. In 2002, 13.9% Whites, 16.7% AAs, 30.8% Hispanics, 15.9% American Indians, and 18.5% Asians were without any source of medical care in the USA [12]. In a study of 3,135 USA counties, low-income counties had a more non-Hispanic Black population, reported poor health, and high rurality rates with a significantly higher cancer death rate in low-medium income counties than high-income counties [29].

A recent study of 149 patients at a safety net hospital undergoing chemotherapy with trastuzumab and/or doxorubicin with 46% Blacks, 27.5% Whites, and 22% Hispanics reported that all populations received the same level of surveillance and treatment, leading to similar outcomes for cardiotoxicity regardless of the race even though White patients were more likely to live in high-income areas [30]. Thus, it is possible to attain equitable outcomes even in underprivileged populations with accessible healthcare.

Disparities in Financial/Economic Stability

Economic stability and healthcare access go hand in hand and unfortunately are tied to racial marginalization. In a study comparing financial toxicity in individuals with atherosclerotic cardiovascular disease (ASCVD), financial toxicity was higher in ASCVD patients than cancer, with an even higher burden in the cardio-oncology population [31]. According to the interview-based survey of 1556 cancer survivors, 32% had financial problems, and those survivors were more likely to forgo medical care and prescription medications when compared to the survivors without financial issues [32]. Another study from five geographically distinct Veterans Administration Hospitals found that 48% population reported difficulty managing with their household income after a median of 7.3 years from cancer diagnosis (89% cancer-free and 11% with advanced cancer), and a high financial burden was associated with poor quality of life [33].

Low income is also related to the probability of being uninsured which has been linked with adverse health outcomes. AAs and Hispanics are much more likely to be uninsured than non-Hispanic Whites [34]. Medicaid insurers had lower cardiovascular mortality compared to uninsured, regardless of the type of cancer in one study [35]. Public insurance or no insurance has shown to be independently associated with progressively higher odds of advanced-stage

disease for nearly all cancer types [36]. Another study demonstrated that uninsured young adults more commonly presented with metastatic disease, less commonly received definitive cancer treatment, and more commonly died from all causes [37]. A childhood cancer survivor report of patients at risk of cardiomyopathy showed that higher-income areas had higher rates of screening with echocardiograms than lower-income areas [38]. Similar results were noted in a different study with higher referral rates to cardio-oncology clinics from higher-income quartile groups [38].

HF is a common manifestation of antineoplastic therapy-associated cardiotoxicity. Patients with HF in lower and middle-income (LMIC) countries are less likely to receive guideline-directed medical therapy (GDMT) as compared to high-income countries. Only 15% of the patients with HF from LMIC were on GDMT 6-months after discharge. Women and patients without health insurance were least likely to be on GDMT [39].

The importance of financial strain and economic stability has been increasingly recognized, and there is a growing focus on addressing the issue. Enhancing survivorship care was one of the ten identified priorities to advance cardio-oncology care by the global cardio-oncology summit in 2019 [40•].

Disparities based on Neighborhood and Rurality

Striking differences exist in the rural and urban populations that affect healthcare access and quality of life. In a study of 6,003 HF patients, rurality was associated with fewer emergency department visits and an increased risk of death [41]. Another study followed 81,418 patients with solid organ cancers and baseline CVD in a Canadian Province for at least one year where rurality, low income, and low education were associated with higher odds of developing new CVD [42]. Rural patients with cancer have been shown to have worse outcomes than their urban counterparts. According to a recent report, the age-adjusted rate of cancer deaths in rural areas from 2011 to 2015 was 180.4 per 100 000 individuals, compared to 157.8 per 100 000 individuals in metropolitan areas [43]. However, according to SWOG (Southwest Oncology Group) trials, enhancing access to uniform treatment strategies for patients with cancer can aid in reducing the disparity in cancer outcomes between rural and urban patients [44].

Our study found that the mortality rate was higher for patients with comorbid cancer and CVD (cardio-oncology population) in the rural counties than their counterparts, regardless of the social vulnerability index [18••]. This highlights that even in relatively lower socially vulnerable parts of the country, people living in the rural counties,

especially those with comorbid cancer and CVD, are more vulnerable and may have suboptimal outcomes.

Disparities and the Role of Environmental Factors

Many cardiovascular conditions and cancers stem from a complex interplay between genetic predisposition and environmental influences. While genetic factors are non-modifiable, environmental influences are highly modifiable and significantly impact how these diseases manifest. The human environment is an amalgamation of two domains—personal and social, which independently predict cardiovascular outcomes [45]. The personal domain comprises physical activity, nutrition, and smoking. 47% of stroke in women and 35% in men have been attributed to poor lifestyle choices [46, 47]. In a cohort of Swedish women, a healthy lifestyle was associated with a 92% decrease in myocardial infarction [48]. The social domain predominantly involves environmental pollution and socioeconomic status. Globally, air pollution is attributed to 7 million deaths/year, most of which are due to CVD [49]. Despite lesser air pollution and climate changes in the rural compared to metropolitan areas, rurality has been associated with worse outcomes as shown by various studies mentioned above. This paradoxical effect highlights how multiple factors and their complex interplay determine outcomes in cardio-oncology patients. Environmental toxins have also been implicated to play a role in various cancers and their progression like breast cancer [50]. Socially vulnerable populations usually suffer the most from climate impacts. They are often the least responsible for crisis and least able to protect themselves from consequential adversities.

While the environmental factors play an established role in both CVD and cancer, there is a dearth of data regarding cardio-oncology patients and remains an interesting area for future research.

Tools and Resources to Measure Social Determinants of Health

Various tools and resources are available to measure SDOH and hence disparities, including mapping tools and indices to measure social determinants based on geographical location. Examples of commonly used indices in the USA include the social vulnerability index [51] (SVI), area deprivation index [52] (ADI), and social deprivation index [53] (SDI). Table 1 illustrates the description of these indices, their uses, and their limitations.

While SVI, SDI, and ADI are more commonly used, other indices are also available and used in the USA. Outside of

the USA, a myriad of indices is available to track the socio-economic status of communities and their progress and vulnerabilities in the context of the healthcare system's performance. Examples include the European deprivation Index (EDI) in many countries across Europe [54], socioeconomic disadvantage index (SEDI) and socioeconomic advantage index (SAI) in Singapore [55], NITI Aayog index in India [56], and the Chinese General Social Survey (CGSS) in China [57].

COVID-19 and its Impact on Disparities in Cardio-oncology

The COVID-19 pandemic has had a remarkable effect on the cardio-oncology population. Patients with active chemotherapy are at increased risk of exposure to COVID-19 and have worse outcomes if infected [58]. Patients with either cancer or CVD are established to have a higher likelihood of adverse events with COVID-19 [59]. In a retrospective study by our group, patients with a history of both cancer and CVD were noted to have a higher risk of experiencing COVID-19-associated adverse outcomes such as the need for mechanical ventilation, shock, or death as compared to patients with cancer or CVD alone [60]. Similarly, of 8,222 hospitalized COVID-19 patients from AHA's cardiovascular disease registry, a history of cancer was a predictor of in-hospital mortality, and recent chemotherapy was associated with poor survival [61]. Frighteningly, due to various restrictions of the pandemic and apprehension about COVID-19, patients are also at increased risk of delay in cancer diagnosis, treatment, and routine healthcare visits. A study of 17 cancer centers in France reported up to a 21% decrease in patients managed with newly diagnosed cancer during the pandemic [62].

The pandemic has had a devastating effect on the economy, and healthcare delivery around the globe and socio-economically disadvantaged populations have been disproportionately affected. A review of 42 studies reported that SDOH are associated with COVID-19 incidence, hospitalization, and outcomes, with strong evidence that race/ethnicity and socioeconomic deprivation were associated with an increased likelihood of COVID-19 incidence and resulting hospitalization. However, evidence on the effect of occupation, education, and housing was limited [63]. A study of 212 young adult cancer survivors during the COVID-19 pandemic showed that 71% of the participants had at least one medical cost-coping behavior, such as skipping or delaying treatment [64].

The International Cardio-Oncology Society (ICOS) has issued a statement on cardio-oncology care in the COVID-19 pandemic with strategies to minimize the risk of COVID-19 implications in cancer patients with CVD,

Table 1 Commonly used indices to measure social determinants of health, their uses, and limitations in USA

Index	Definition	Description	Uses and limitations
Social Vulnerability Index (SVI)	SVI uses US Census data to determine the social vulnerability of every census tract. Census tracts are subdivisions of counties for which the Census collects statistical data	SVI ranks each tract on 15 social factors, including poverty, lack of vehicle access, and crowded housing, and groups them into four related themes 1.Socioeconomic Status 2.Household Composition 3.Race/Ethnicity/Language 4.Housing/Transportation	Useful for large geographical regions Includes race/ethnicity
Social Deprivation Index (SDI)	SDI is a composite measure of area-level deprivation based on seven demographic characteristics collected in the American Community Survey and used to quantify the socioeconomic variation in health outcomes	SDI is a composite measure of 7 demographic characteristics collected in the American Community Survey: 1.Percent living in poverty 2.Percent with less than 12 years of education 3.Percent single-parent household 4.Percent living in the rented housing unit 5.Percent living in the overcrowded housing unit 6.Percent of households without a car 7.Percent non-employed adults under 65 years of age	Multidimensional measures of deprivation and not just poverty Can mask the likely variation and heterogeneity within counties
Area Deprivation Index (ADI)	ADI can show where areas of deprivation and affluence exist within a community	ADI is calculated with 17 indicators from the American Community Survey has been well-studied in the peer-reviewed literature since 2003 and used for 20 years by the Health Resources and Services Administration (HRSA). The following four domains have 17 indicators 1.Education 2.Income 3.Housing 4.Household Characteristics	Useful for small geographical regions Does not include race/ethnicity

including expanding the use of cardiac biomarkers to screen for cardiotoxicity rather than cardiac imaging and use of telehealth [65]. Telemedicine (including E-consults, telephone, and video consultations) can also be used as an opportunity to enhance access to health care in remote areas lacking cardio-oncology services. Such measures, in the long run, could help break some of the social barriers and bring more equitable cardio-oncology care to vulnerable communities worldwide.

Opportunities for Improvement

1. Targeted Policy Intervention and Resource Allocation
Patients afflicted with a dual diagnosis of cancer and CVD are highly vulnerable to disparities leading to adverse outcomes in this population and thus require

special attention and equitable access to quality preventive, diagnostic, and therapeutic services. To attain healthcare equity, we need to realize the importance of achieving vertical (greater healthcare use by those with greater needs) and horizontal (equal healthcare use by those with equal needs) equity at the community level, which would require investment in healthcare infrastructure in socially vulnerable areas.

While it is clear that health outcomes in marginalized communities are worse, the required steps to attain equity and optimal outcomes are not clear. Policymakers and community leaders should recognize that one size would not fit all, and policies must be tailored to the community's needs. Merely physical access to quality healthcare is not adequate. Our study demonstrated that while the mortality rate in the cardio-oncology population was worse in rural counties across the social vulner-

ability quartiles, the graded increase in mortality across SVI quartiles was not different based on the rural-urban divide, and the outcomes were worse in more socially vulnerable counties even if they were in urban or semi-urban locations [18••]. Thus, mere proximity of the high-quality healthcare facility may not solve the problem as there are many other dimensions to barriers to access. To reduce the disparities in health outcomes, we need to utilize public health resources in a targeted way to make healthcare more i) accessible, ii) affordable, iii) culturally acceptable, iv) and focused on community-based preventive care and well-being.

2. Increase Access to Cardio-oncology Care

Despite increased awareness of the spectrum of cardio-oncology, the field is still growing. There are a limited number of cardio-oncology clinics and practicing physicians providing care to cancer patients with CVD. A national cardio-oncology survey of 444 adult and pediatric cardiology division chiefs and program directors conducted in 2014 showed that 39% of the participants did not feel comfortable taking care of cancer patients with CVD. 44% of respondents attributed the lack of funding and national guidelines as the most concerning roadblocks in developing a cardio-oncology program [66]. An electronic survey of general cardiology fellowship program directors in 2018 about the exposure to cardio-oncology in fellowship programs showed that 51% of the responder programs were a part of centers offering dedicated cardio-oncology services compared to 27% from a survey in 2014. Similarly, less than 10% of the cardiovascular training programs provide focused training in cardio-oncology [67].

While dedicated training in cardio-oncology is emerging, it is limited to a small number of highly specialized centers. Most patients with cancer are cared for by community-based practices and cardiologists without specialized training. It is thus important to provide necessary knowledge pertaining to this patient

population during cardiovascular disease fellowship training [68]. Both cardiology and oncology trainees, as well as practitioners globally, should be encouraged to participate in international meetings and workshops providing comprehensive education on various topics of cardio-oncology such as those organized by the ACC and ICOS to enhance the know-how of the subject and in turn access to quality care everywhere.

3. Inclusion of All Races in Clinical Trials

Black adults and other racial minorities have been significantly underrepresented in the CVD trials [69] and oncology trials. For example, an analysis of global phase-1 trials of biopharmaceutical oncology agents showed that 62% of the participants were White. In the USA, 82.4% of the population was White, 7.3% were AAs, 3.4% were Asians, and 2.8% were Hispanic/Latinos and other races [70]. The underrepresentation of marginalized populations may undermine the generalizability of the trial findings and mask the heterogeneity of outcomes adverse events. Future trials should be designed to represent all racial and ethnic groups appropriately. This can be done by setting defined targets of enrollment of non-White minorities, increasing language adaptation of the education material, building community partnership for shared decision-making, and using patient navigators [71]. Additionally, clinical trials, if feasible, should be performed in multiple countries to ensure global diversity and not just diversity within the USA.

4. Utilization of Social Media to Increase Health Literacy

Social media has a powerful impact on the audience and can increase health literacy in the general population and among physicians. This includes social networking sites such as Twitter, Facebook, Instagram, media sharing sites such as YouTube, and weblogs or blogs. These platforms are a relatively inexpensive tool that can increase the awareness of cardio-oncology among both healthcare providers and the public [72, 73]. Journal

Table 2 Various levels of research and suggested research questions to understand the impact of disparities in cardio-oncology and develop strategies to mitigate

Levels of Research	Research Questions
Individual level	<ul style="list-style-type: none"> ■ How do individual behaviors impact healthcare decisions? ■ Are the individual's decisions affected by the circumstances they find themselves in? For example, healthcare access, socioeconomic status
Interpersonal level	<ul style="list-style-type: none"> ■ Do clinical interactions affect disparities in health care? ■ What is the role of physician bias? ■ Do clinicians address the social determinants of health and incorporate them in medical decision-making?
Organization level	<ul style="list-style-type: none"> ■ How do healthcare systems and institutional practices influence health disparities? ■ What interventions can be done at an organizational level to reduce these disparities?
National level	<ul style="list-style-type: none"> ■ What is the role of national policies in addressing the disparities? ■ How can policy implementation help achieve health equity?

of American College of Cardiology: Cardio-oncology (JACC CardioOncology) social media ("SoMe") platform has received commendable responses [74]. An analysis of Twitter use for cardio-oncology from 2014 to 2018 during five major cardiology and oncology meetings showed that Twitter users increased 597% from 2014 to 2018. 73.5% of the total analyzed tweets were from physicians [72]. Social media platforms can be an essential promoter of public health if used correctly and within the guidelines provided by healthcare organizations and societies.

5. Integration of SDOH in Clinical Care Delivery

The screening and documentation of SDOH in medical records can be an important driver to resolve health inequities. In a cross-sectional study of 4976 physician practices and 1628 USA hospitals from 2017 to 2018, 16% of physicians and 28% of hospitals reported screening for transportation needs, utility needs, housing instability, and food insecurity [73]. International Classification of Diseases, Tenth Revision, Clinical Modification codes (ICD-10 CM) has a subset of codes called Z codes (Z55-65) to document the SDOH in electronic medical records. A retrospective analysis of documentation of SDOH in electronic health records from 2015 to 2018 showed a low rate of utilization of ICD-10 CM-Z codes [75]. Underscreening of the SDOH is one of the reasons behind the under-utilization of these ICD codes. Some challenges to documentation include the high workload of physicians and lack of familiarity with Z-codes. This can partly be addressed if SDOH documentation is supported by nurses, case managers, physician assistants, and even patients interacting with their own electronic medical records to incorporate the data in their charts. In fact, AHA coding clinic's official guidelines on coding and reporting in 2018 officially allowed clinicians (including non-physician providers) to document the SDOH in the electronic record systems [76]. The availability of real-time data on SDOH will enable healthcare providers to identify vulnerable patients and provide actionable information at the point of care.

6. Opportunities for Research

Realization and recognition of the magnitude of a problem are the first step toward its elimination. There are limited data on disparities that exist in cardio-oncology and how they affect patient care and outcomes providing innumerable research opportunities. This can be divided into the individual, interpersonal, organization, and national levels as summarized in Table 2.

Big data can be an invaluable tool in research related to health inequities. Zhang et al. explained how big data science offers multiple opportunities to reduce health disparities and improve minority health [77]. These include the incorporation of insurance, demographics, and SDOH

information in electronic medical records. Big data can also be used to improve public health surveillance and monitoring and cannot only identify the disparities but also help track the trends in these disparities and their effects on patient outcomes.

Future Directions

While our understanding of disparities, the role of various social determinants, and their crucial interplay with an individual's health has increased, it is primarily based on retrospective and aggregate data. Prospective data on how such disparities impact an individual's health and outcomes of various investigational and established cancer and CVD-related health interventions are lacking. To study these issues at a granular level, which will help us take targeted and pragmatic actions to reduce the disparities, we need to integrate various individualized SDOH parameters in prospective clinical trials and registry data collection.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References:

Papers of particular interest, published recently, have been highlighted as:

- Of importance
- Of major importance

1. Siegel RL, Miller KD, Fuchs HE, Jemal A. Cancer Statistics, 2021. *CA Cancer J Clin.* 2021;71:7–33.
2. Global Burden of Disease Cancer Collaboration, Fitzmaurice C, Abate D, Abbasi N, Abbastabar H, Abd-Allah F, et al. Global, Regional, and National Cancer Incidence, Mortality, Years of Life Lost, Years Lived With Disability, and Disability-Adjusted Life-Years for 29 Cancer Groups, 1990 to 2017: A Systematic Analysis for the Global Burden of Disease Study. *JAMA Oncol.* 2019;5:1749–68.
3. Stoltzfus KC, Zhang Y, Sturgeon K, Sinoway LI, Trifiletti DM, Chinchilli VM, et al. Fatal heart disease among cancer patients. *Nat Commun.* 2020;11:2011.
4. Social Determinants of Health - Healthy People 2030 | health.gov [Internet]. [cited 2022 Jan 26]. Available from: <https://health.gov/healthypeople/objectives-and-data/social-determinants-health>

5. Marmot M, Friel S, Bell R, Houweling TAJ, Taylor S, Commission on Social Determinants of Health. Closing the gap in a generation: health equity through action on the social determinants of health. *Lancet*. 2008;372:1661–9.
6. Havranek EP, Mujahid MS, Barr DA, Blair IV, Cohen MS, Cruz-Flores S, et al. Social Determinants of Risk and Outcomes for Cardiovascular Disease: A Scientific Statement From the American Heart Association. *Circulation*. 2015;132:873–98.
7. White-Williams C, Rossi LP, Bittner VA, Driscoll A, Durant RW, Granger BB, et al. Addressing Social Determinants of Health in the Care of Patients With Heart Failure: A Scientific Statement From the American Heart Association. *Circulation*. 2020;141:e841–63.
8. Alcaraz KI, Wiedt TL, Daniels EC, Yabroff KR, Guerra CE, Wender RC. Understanding and addressing social determinants to advance cancer health equity in the United States: A blueprint for practice, research, and policy. *CA Cancer J Clin*. 2020;70:31–46.
9. Coughlin SS. Social determinants of breast cancer risk, stage, and survival. *Breast Cancer Res Treat*. 2019;177:537–48.
10. Ma J, Jemal A, Fedewa SA, Islami F, Lichtenfeld JL, Wender RC, et al. The American Cancer Society 2035 challenge goal on cancer mortality reduction. *CA Cancer J Clin*. 2019;69:351–62.
11. Zavala VA, Bracci PM, Carethers JM, Carvajal-Carmona L, Coggins NB, Cruz-Correa MR, et al. Cancer health disparities in racial/ethnic minorities in the United States. *Br J Cancer*. 2021;124:315–32.
12. Ward E, Jemal A, Cokkinides V, Singh GK, Cardinez C, Ghafoor A, et al. Cancer disparities by race/ethnicity and socioeconomic status. *CA Cancer J Clin*. 2004;54:78–93.
13. Miller KD, Goding Sauer A, Ortiz AP, Fedewa SA, Pinheiro PS, Tortolero-Luna G, et al. Cancer Statistics for Hispanics/Latinos, 2018. *CA Cancer J Clin*. 2018;68:425–45.
14. Hasan S, Dinh K, Lombardo F, Kark J. Doxorubicin cardiotoxicity in African Americans. *J Natl Med Assoc*. 2004;96:196–9.
15. Sapkota Y, Qin N, Ehrhardt MJ, Wang Z, Chen Y, Wilson CL, et al. Genetic Variants Associated with Therapy-Related Cardiomyopathy among Childhood Cancer Survivors of African Ancestry. *Cancer Res*. 2021;81:2556–65.
16. Litvak A, Batukbhai B, Russell SD, Tsai H-L, Rosner GL, Jeter SC, et al. Racial disparities in the rate of cardiotoxicity of HER2-targeted therapies among women with early breast cancer. *Cancer*. 2018;124:1904–11.
17. Al-Sadawi M, Hussain Y, Copeland-Halperin RS, Tobin JN, Moskowitz CS, Dang CT, et al. Racial and Socioeconomic Disparities in Cardiotoxicity Among Women With HER2-Positive Breast Cancer. *Am J Cardiol*. 2021;147:116–21.
- 18.●● Ganatra S, Dani SS, Kumar A, Khan SU, Wadhwa R, Neilan TG, et al. Impact of Social Vulnerability on Mortality Secondary to Comorbid Cancer and Cardiovascular Disease in the United States. *JACC CardioOncol*. **(This study demonstrates that age adjusted mortality rates in cardio-oncology patients were higher in counties with greater social vulnerability)**.
19. Wexler LH, Andrich MP, Venzon D, Berg SL, Weaver-McClure L, Chen CC, et al. Randomized trial of the cardioprotective agent ICRF-187 in pediatric sarcoma patients treated with doxorubicin. *J Clin Oncol*. 1996;14:362–72.
20. Marty M, Espié M, Llombart A, Monnier A, Rapoport BL, Stahlova V, et al. Multicenter randomized phase III study of the cardioprotective effect of dexrazoxane (Cardioxane) in advanced/metastatic breast cancer patients treated with anthracycline-based chemotherapy. *Ann Oncol*. 2006;17:614–22.
21. Negishi T, Thavendiranathan P, Negishi K, Marwick TH, SUCCOUR investigators. Rationale and Design of the Strain Surveillance of Chemotherapy for Improving Cardiovascular Outcomes: The SUCCOUR Trial. *JACC Cardiovasc Imaging*. 2018;11:1098–105.
22. Gong IY, Tan NS, Ali SH, Lebovic G, Mamdani M, Goodman SG, et al. Temporal Trends of Women Enrollment in Major Cardiovascular Randomized Clinical Trials. *Can J Cardiol*. 2019;35:653–60.
23. Humphries KH, Izadnegahdar M, Sedlak T, Saw J, Johnston N, Schenck-Gustafsson K, et al. Sex differences in cardiovascular disease - Impact on care and outcomes. *Front Neuroendocrinol*. 2017;46:46–70.
24. Sheppard R, Bedi M, Kubota T, Semigran MJ, Dec W, Holubkov R, et al. Myocardial expression of fas and recovery of left ventricular function in patients with recent-onset cardiomyopathy. *J Am Coll Cardiol*. 2005;46:1036–42.
25. Silber JH, Jakacki RI, Larsen RL, Goldwein JW, Barber G. Increased risk of cardiac dysfunction after anthracyclines in girls. *Med Pediatr Oncol*. 1993;21:477–9.
26. Khalid Y, Fradley M, Dasu N, Dasu K, Shah A, Levine A. Gender disparity in cardiovascular mortality following radiation therapy for Hodgkin's lymphoma: a systematic review. *Cardio-oncology*. 2020;6:12.
27. Nipp RD, Shui AM, Perez GK, Kirchoff AC, Peppercorn JM, Moy B, et al. Patterns in Health Care Access and Affordability Among Cancer Survivors During Implementation of the Affordable Care Act. *JAMA Oncol*. 2018;4:791–7.
28. Report of the Secretary's Task Force on Black & Minority Health - Digital Collections - National Library of Medicine [Internet]. [cited 2021 Dec 12]. Available from: <https://collections.nlm.nih.gov/catalog.nlm.nlmuid-8602912-mvset>
29. O'Connor JM, Sedghi T, Dhodapkar M, Kane MJ, Gross CP. Factors Associated With Cancer Disparities Among Low-, Medium-, and High-Income US Counties. *JAMA Netw Open*. 2018;1:e181235.
30. Chen CB, Dalsania RK, Hamad EA. Healthcare disparities in cardio-oncology: patients receive same level of surveillance regardless of race at a safety net hospital. *Cardiooncology*. 2021;7:3.
31. Valero-Elizondo J, Chouairi F, Khera R, Grandhi GR, Saxena A, Warraich HJ, et al. Atherosclerotic Cardiovascular Disease, Cancer, and Financial Toxicity Among Adults in the United States. *JACC CardioOncol*. 2021;3:236–46.
32. Kent EE, Forsythe LP, Yabroff KR, Weaver KE, de Moor JS, Rodriguez JL, et al. Are survivors who report cancer-related financial problems more likely to forgo or delay medical care? *Cancer*. 2013;119:3710–7.
33. Zafar SY, McNeil RB, Thomas CM, Lathan CS, Ayanian JZ, Provenzale D. Population-based assessment of cancer survivors' financial burden and quality of life: a prospective cohort study. *J Oncol Pract*. 2015;11:145–50.
34. Gaps in Health Insurance: An All-American Problem [Internet]. 2006 [cited 2022 Apr 16]. Available from: <https://www.commonwealthfund.org/publications/fund-reports/2006/apr/gaps-health-insurance-all-american-problem>
35. Shi T, Jiang C, Zhu C, Wu F, Fotjhadhi I, Zarich S. Insurance disparity in cardiovascular mortality among non-elderly cancer survivors. *Cardiooncology*. 2021;7:11.
36. Rosenberg AR, Kroon L, Chen L, Li CI, Jones B. Insurance status and risk of cancer mortality among adolescents and young adults. *Cancer*. 2015;121:1279–86.
37. Aizer AA, Falit B, Mendu ML, Chen M-H, Choueiri TK, Hoffman KE, et al. Cancer-specific outcomes among young adults without health insurance. *J Clin Oncol*. 2014;32:2025–30.
38. Caplin DA, Smith KR, Ness KK, Hanson HA, Smith SM, Nathan PC, et al. Effect of Population Socioeconomic and Health System Factors on Medical Care of Childhood Cancer Survivors: A Report from the Childhood Cancer Survivor Study. *J Adolesc Young Adult Oncol*. 2017;6:74–82.
39. Tromp J, Ouwkerk W, Teng T-HK, Cleland JGF, Bamadhaj S, Angermann CE, et al. Global disparities in prescription of

- guideline-recommended drugs for heart failure with reduced ejection fraction. *Eur Heart J*. 2022;ehac103.
40. Lenihan DJ, Fradley MG, Dent S, Brezden-Masley C, Carver J, Filho RK, et al. Proceedings From the Global Cardio-Oncology Summit: The Top 10 Priorities to Actualize for CardioOncology. *JACC CardioOncol*. 2019;1:256–72 (**Reducing financial toxicity and expanding financial resources are crucial in increasing survivorship care, according to one of the ten identified priorities to advance cardio-oncology care by the global cardio-oncology summit in 2019**).
 41. Manemann SM, St Sauver J, Henning-Smith C, Finney Rutten LJ, Chamberlain AM, Fabbri M, et al. Rural, Death, and Healthcare Utilization in Heart Failure in the Community. *J Am Heart Assoc*. 2021;10:e018026.
 42. Batra A, Kong S, Cheung WY. Associations of Socioeconomic Status and Rurality With New-Onset Cardiovascular Disease in Cancer Survivors: A Population-Based Analysis. *JCO Oncol Pract*. 2021;17:e1189–201.
 43. Henley SJ, Anderson RN, Thomas CC, Massetti GM, Peaker B, Richardson LC. Invasive Cancer Incidence, 2004–2013, and Deaths, 2006–2015, in Nonmetropolitan and Metropolitan Counties - United States. *MMWR Surveill Summ*. 2017;66:1–13.
 44. Unger JM, Moseley A, Symington B, Chavez-MacGregor M, Ramsey SD, Hershman DL. Geographic Distribution and Survival Outcomes for Rural Patients With Cancer Treated in Clinical Trials. *JAMA Netw Open*. 2018;1:e181235.
 45. Bhatnagar A. Environmental Determinants of Cardiovascular Disease. *Circ Res*. 2017;121:162–80.
 46. Kessler KM. Primary prevention of coronary heart disease in women through diet and lifestyle. *N Engl J Med*. 2000;343:1814–15 author reply
 47. Primary prevention of stroke by healthy lifestyle - PubMed [Internet]. [cited 2022 Apr 16]. Available from: <https://pubmed.ncbi.nlm.nih.gov/18697819/>
 48. Akesson A, Weismayer C, Newby PK, Wolk A. Combined effect of low-risk dietary and lifestyle behaviors in primary prevention of myocardial infarction in women. *Arch Intern Med*. 2007;167:2122–7.
 49. Cosselman KE, Navas-Acien A, Kaufman JD. Environmental factors in cardiovascular disease. *Nat Rev Cardiol*. 2015;12:627–42.
 50. Koual M, Tomkiewicz C, Cano-Sancho G, Antignac J-P, Bats A-S, Coumoul X. Environmental chemicals, breast cancer progression and drug resistance. *Environ Health*. 2020;19:117.
 51. CDC/ATSDR's Social Vulnerability Index (SVI) [Internet]. 2021 [cited 2021 Nov 16]. Available from: <https://www.atsdr.cdc.gov/placeandhealth/svi/index.html>
 52. Singh GK. Area deprivation and widening inequalities in US mortality, 1969–1998. *Am J Public Health*. 2003;93:1137–43.
 53. Social Deprivation Index (SDI) [Internet]. [cited 2021 Nov 16]. Available from: <https://www.graham-center.org/rgc/maps-data-tools/sdi/social-deprivation-index.html>
 54. Launoy G, Launay L, Dejardin O, Bryère J, Guillaume E. European Deprivation Index: designed to tackle socioeconomic inequalities in cancer in Europe. *Eur J Public Health*. 2018;28:cky213.625.
 55. Earnest A, Ong MEH, Shahidah N, Chan A, Wah W, Thumboo J. Derivation of indices of socioeconomic status for health services research in Asia. *Prev Med Rep*. 2015;2:326–32.
 56. Water Index [Internet]. [cited 2022 Jan 27]. Available from: <http://social.niti.gov.in/water-index>
 57. Home-中国综合社会调查 [Internet]. [cited 2022 Jan 27]. Available from: <http://cgss.ruc.edu.cn/English/Home.htm>
 58. Addison D, Campbell CM, Guha A, Ghosh AK, Dent SF, Jneid H. Cardio-Oncology in the Era of the COVID-19 Pandemic and Beyond. *J Am Heart Assoc*. 2020;9:e017787.
 59. Ganatra S, Hammond SP, Nohria A. The Novel Coronavirus Disease (COVID-19) Threat for Patients With Cardiovascular Disease and Cancer. *JACC: CardioOncology*. American College of Cardiology Foundation; 2020;2:350–5.
 60. Ganatra S, Dani SS, Redd R, Rieger-Christ K, Patel R, Parikh R, et al. Outcomes of COVID-19 in Patients With a History of Cancer and Comorbid Cardiovascular Disease. *J Natl Compr Canc Netw*. 2020;1–10. (**According to this study, patients with a history of both cancer and cardiovascular disease had a higher risk of experiencing COVID-19-associated adverse outcomes as compared to patients with cancer or cardiovascular disease alone**).
 61. Tehrani DM, Wang X, Rafique AM, Hayek SS, Herrmann J, Neilan TG, et al. Impact of cancer and cardiovascular disease on in-hospital outcomes of COVID-19 patients: results from the American Heart Association COVID-19 Cardiovascular Disease Registry. *CardioOncology*. 2021;7:28.
 62. Blay JY, Boucher S, Le Vu B, Cropet C, Chabaud S, Perol D, et al. Delayed care for patients with newly diagnosed cancer due to COVID-19 and estimated impact on cancer mortality in France. *ESMO Open*. 2021;6:100134.
 63. Upshaw TL, Brown C, Smith R, Perri M, Ziegler C, Pinto AD. Social determinants of COVID-19 incidence and outcomes: A rapid review. *PLoS One*. 2021;16:e0248336.
 64. Thom B, Benedict C, Friedman DN, Watson SE, Zeitler MS, Chino F. Economic distress, financial toxicity, and medical cost-coping in young adult cancer survivors during the COVID-19 pandemic: Findings from an online sample. *Cancer*. 2021;127:4481–91.
 65. Lenihan D, Carver J, Porter C, Liu JE, Dent S, Thavendirathan P, et al. Cardio-oncology care in the era of the coronavirus disease 2019 (COVID-19) pandemic: An International Cardio-Oncology Society (ICOS) statement. *CA Cancer J Clin*. 2020;70:480–504.
 66. Barac A, Murtagh G, Carver JR, Chen MH, Freeman AM, Herrmann J, et al. Cardiovascular Health of Patients With Cancer and Cancer Survivors: A Roadmap to the Next Level. *J Am Coll Cardiol*. 2015;65:2739–46.
 67. Hayek SS, Ganatra S, Lenneman C, Scherrer-Crosbie M, Leja M, Lenihan DJ, et al. Preparing the Cardiovascular Workforce to Care for Oncology Patients: JACC Review Topic of the Week. *J Am Coll Cardiol*. 2019;73:2226–35.
 68. Ganatra S, Hayek SS. Cardio-Oncology for GenNext: A Missing Piece of the Training Puzzle. *J Am Coll Cardiol*. 2018;71:2977–81.
 69. Prasanna A, Miller HN, Wu Y, Peeler A, Ogungbe O, Plante TB, et al. Recruitment of Black Adults into Cardiovascular Disease Trials. *J Am Heart Assoc*. 2021;10:e021108.
 70. Camidge DR, Park H, Smoyer KE, Jacobs I, Lee LJ, Askerova Z, et al. Race and ethnicity representation in clinical trials: findings from a literature review of Phase I oncology trials. *Future Oncol*. 2021;17:3271–80.
 71. Vuong I, Wright J, Nolan MB, Eggen A, Bailey E, Strickland R, et al. Overcoming Barriers: Evidence-Based Strategies to Increase Enrollment of Underrepresented Populations in Cancer Therapeutic Clinical Trials—a Narrative Review. *J Cancer Educ*. 2020;35(5):841–9. <https://doi.org/10.1007/s13187-019-01650-y>.
 72. Jackson SB, Tanoue M, Shahandeh N, Lopez-Mattei J, Brown S-A, Han JK, et al. #Cardioonc: Are We Reaching Across the Digital Aisle? *JACC CardioOncol*. 2021;3:457–60.
 73. Frazee TK, Brewster AL, Lewis VA, Beidler LB, Murray GF, Colla CH. Prevalence of Screening for Food Insecurity, Housing Instability, Utility Needs, Transportation Needs, and Interpersonal Violence by US Physician Practices and Hospitals. *JAMA Netw Open*. 2019;2:e1911514.
 74. Brown S-A, Yang EH, Reza N, Guha A, Ismail-Khan R, Pemmaraju N, et al. #JACCCardioOnc: Evolution of a

- Dedicated Social Media Strategy for JACC: CardioOncology. *JACC CardioOncol.* 2021;3:461–4.
75. Guo Y, Chen Z, Xu K, George TJ, Wu Y, Hogan W, et al. International Classification of Diseases, Tenth Revision, Clinical Modification social determinants of health codes are poorly used in electronic health records. *Medicine (Baltimore)*. 2020;99:e23818.
76. Resource on ICD-10-CM Coding for Social Determinants of Health | AHA [Internet]. [cited 2021 Nov 16]. Available from: <https://www.aha.org/dataset/2018-04-10-resource-icd-10-cm-coding-social-determinants-health>
77. Zhang X, Pérez-Stable EJ, Bourne PE, Peprah E, Duru OK, Breen N, et al. Big Data Science: Opportunities and Challenges to Address Minority Health and Health Disparities in the 21st Century. *Ethn Dis.* 2017;27:95–106.

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