HHS Public Access

Author manuscript

J Public Health Manag Pract. Author manuscript; available in PMC 2017 December 20.

Published in final edited form as:

J Public Health Manag Pract. 2016 ; 22(Suppl 1): S68–S76. doi:10.1097/PHH.0000000000000346.

Integrating Equity in a Public Health Funding Strategy

Kristy T. Joseph, MA, **Ketra Rice, PhD, MS**, and **Chunyu Li, MD, PhD**

Division of Cancer Prevention and Control, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia

Abstract

Objective—Equity can be valuable to guide decision makers about where to target funds; however, there are few studies for modeling vertical equity in public health program funding strategies. This case study modeled vertical equity in the funding strategy of the Centers for Disease Control and Prevention's Colorectal Cancer Control Program.

Design—To integrate vertical equity by using historical funding and health data, we (*a*) examined the need for colorectal cancer screening, (*b*) conducted multiple regressions to examine the relationship between factors of need and funding of states, (*c*) stratified states into similar need groups, (*d*) estimated vertical equity within groups, and (*e*) assessed equity in the funding distribution.

Results—Certain states with similar needs had high relative funding, whereas other states with similar needs had low relative funding.

Conclusion—The methods used to integrate vertical equity in this case study could be applied in publicly funded programs to potentially minimize inequities and improve outcomes.

Keywords

disparity; funding allocation process; horizontal equity; public health; resource allocation; vertical equity

Social justice is a core principle in public health that aims to improve population health by equalizing access and opportunity to resources for achieving good health, especially among people in vulnerable circumstances.[1–3] This vulnerability to poor health is known as health disparities. Health disparities exist when differences in health outcomes or health determinants are observed among populations, and those differences can be attributed to economic, social, or environmental disadvantage.[4] In the United States, health disparities are widely spread across every domain of public health, and one of the primary goals in national initiatives, such as *Healthy People 2020*, is to reduce disparities.[4–7] Disparities in colorectal cancer (CRC) incidence are particularly evidenced within our Centers for Disease Control and Prevention (CDC)-funded Colorectal Cancer Control Program (CRCCP), where CRC

Correspondence: Kristy T. Joseph, MA, Division of Global Health Protection, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, 1600 Clifton Rd, MS E-93, Atlanta, GA 30329 (vio5@cdc.gov).

The authors declare no conflicts of interest.

incidence rates range from 33.6 (Colorado) to 57.8 (South Dakota) per 100 000 people in their state populations.[8]

Health equity is social justice for health and is the principle underlying a commitment to reduce health disparities.[9] Health equity can be viewed in various ways; one in particular is the notion of distributive justice, which is to equitably allocate resources to reduce disparities and improve health outcomes.[4] Equity in resource allocation incorporates concepts of need in the allocation strategy. Need may refer to adjustable factors such as medically underserved areas, lack of funds for health services, and risky health behaviors. Integrating the concept of equity in the funding strategy of public health programs can be a viable mechanism for achieving a just distribution of resources, which can aid in attaining social justice and reducing health disparities.[4,9,10]

A number of strategies and processes are employed to award and distribute funds among states and other jurisdictions. The CDC typically awards states by using a competitive application procedure that uses a standard objective review process in which local contexts for the funds are closely considered.[11] Accordingly, some CDC programs tie funding decisions to performance information through a performance-based grants management process (T. H. Poister, PhD, O. Q. Pasha, PhD, A. DeGroff, PhD, J. Royalty, MS, K. T. Joseph, MA, unpublished data, 2014).[12] Such performance-based strategies aim to improve performance of public health programs and strengthen accountability of how federal funds are used. Some public health programs use optimization models, or formula-based models, to allocate funds.[11,13,14] Formula-based models use a mathematical calculation that accounts for state-based factors, such as the proportionate share of the national population or proportionate share of low-income residents, compared with the national low-income population.[15]

Each funding strategy has its own pros and cons. Some strategies may consider need in the calculation to address health disparities; however, they usually measure need by using 1 or 2 simple indicators, such as the size of the target population by state or incidence of disease by state. So far, no funding strategy has comprehensively considered need in its model. In addition, few studies are available about the modeling and estimation of an equity measure to guide resource allocation in federal public health programs.[16]

The purpose of this article is to introduce a practical approach to integrate equity in funding strategies for public health programs. Using CDC's CRCCP as a case study example, we show how integrating equity can guide decision makers to make funding allocation decisions. This article is arranged as follows: we begin with a background of the CRCCP and the principles of equity. Then, we describe our 5-step methodological process by using the CRCCP as an example. Finally, we provide results of our analysis and discuss the implications and future areas of work for this study.

Background of CDC's CRCCP

CDC's CRCCP, which began in 2009, funded 25 states and 4 tribal organizations through grant-based funding via cooperative agreements.[17] Grants for the program are typically

awarded to state health departments and tribal health agencies. The goal of the CRCCP is to increase CRC screening prevalence to 80% in funded states and tribal organizations.[17,18] The CDC recommends that states implement evidence-based activities to increase population use of CRC screening.[17] Diversity in population and health environments in states present unique challenges for each state to reach the CRCCP goal.[17] At the inception of our analysis, the CRCCP was in its final year of a 5-year cooperative agreement, which allowed us to include historical funding data in our analysis.

Principles of Equity

Although often overlooked in public health studies, the principle of distributive justice, or funding equity, has been well established in the taxation and education literature.[19–28] The application of equity revolves around 2 principles: horizontal equity and vertical equity.[9,19,20–27] Horizontal equity is defined as the equal treatment of equals, or the sameness, and is contextualized by fair outcomes. In the context of public health, horizontal equity may be described as equal funding to states with equal sized populations. However, an inherent limitation of horizontal equity is in its assumption that the external environment, or the capacity of each state program, is equal (ie, equal size of population requires equal amount of funding).[27] In contrast, vertical equity is defined as the unequal, but fair treatment of unequals, and is contextualized by a fair process.[21,22] In the context of public health, vertical equity may be described as a funding allocation corresponding to needs in states reflected by their diverse sizes and levels of risk in the population. Thus, vertical equity attempts to connect funding to the needs of states beyond population size. This is especially important for federal public health programs that target disadvantaged subpopulations, such as the CRCCP.

Researchers in education finance have been front-runners in modeling vertical equity measures for funding allocation across school districts.[23–28] Vertical equity was introduced in school financing by acknowledging that different educational environments warrant different resources specific to need.[20–27] Applying vertical equity in school finance improved the responsiveness of schools or school districts adapting to shifting risk factors among students and enabled district administrators to recognize disparities and allocate a proportionately greater share of funds to schools with greater needs.[23] By recognizing different educational environments and allocating resources accordingly, vertical equity proved to be a valuable tool for funding of public education. It is reasonable to assume that extensions of vertical equity may be a valuable tool for funding of public health programs as well.

Methods

A 5-step process was applied to develop and model a vertical measure of equity for the CRCCP. First, because vertical equity is concerned with differences, CRCCP population- and state-level CRC risk factors were identified and are described in further detail in the following text. Second, multiple regressions were conducted to examine the relationship between risk factors, funding level, and the CRC at-risk rate within each state. All 25 CRCCP states were included in the analyses. Third, on the basis of the regression results,

states were stratified into groups with similar CRC screening need. Fourth, a vertical equity point was calculated for each state to assess the level of need per state within each group. Finally, equity in the distribution of funds was assessed.

Variables used to measure vertical equity

Outcomes from 2 regression models were used to measure vertical equity. Dependent variables included (1) the screening need or CRC at-risk rate (the unscreened persons and those not up-to-date with CRC screening) in each state on the basis of CDC's Behavioral Risk Factor Surveillance System, and (2) the annual average CRCCP award for each state on the basis of 2009–2013 funding data. The at-risk rate was estimated because the goal of the CRCCP is to increase the screening rate in each state to 80%.

Explanatory variables include both population- and state-level characteristics that reflect risk factors for CRC. These variables were included on the basis of prior empirical evidence of risk factors related to CRC.[28–40] We limited our analysis to those variables that could be modifiable by public health programs or by policies and data readily accessible at the population level. Related descriptive statistics of these variables aggregated for the 25 states are presented in the Table. US Census data were used to estimate the total target population aged 50 to 75 years on the basis of the US Preventive Services Task Force recommendation of CRC screening for individuals in that age group. The proportion of the CRC at-risk population out of the total target population was defined as the population ratio.[18] Other population-level characteristics include current smoking and excessive drinking prevalence among the target population, as these health behaviors are associated with an increased risk for various chronic diseases, including CRC.[29–31] US Census data also estimated the percentage of low-income, uninsured adults aged 50 to 64 years (individuals older than 64 years were assumed to be insured, as they are eligible for Medicare). The unemployment rate per state was included because the unemployed often face greater barriers to medical services, receive fewer preventive services for chronic diseases, including cancer screening, and are more likely to report negative health status.[32–35] State-level characteristics included rurality as a proxy for geographic accessibility and the density of primary care physicians (PCPs) in rural areas. Rural communities often face greater barriers to health services, especially preventive care, which may result in higher health inequalities.[35,36] Lower density of PCPs has been associated with a higher incidence and death rates of CRC.[27–39]

Modeling vertical equity

Incorporating measures of vertical equity, 2 multivariable regressions were developed to estimate the predicted funding award (1) and predicted at-risk rate (2) for each state:

$$\begin{aligned}\mathrm{CRCCP\_FundingAward}_j = {} & \beta_{0j} + \beta_{1j}{}^{*}(\mathrm{Smoking}_j) \\ & + \beta_{2j}{}^{*}(\mathrm{Alcohol}_j) + \beta_{3j}{}^{*}(\mathrm{LowIncome\_Uninsured}_j) \\ & + \beta_{4j}{}^{*}(\mathrm{Unemployed}_j) + \beta_{5j}{}^{*}(\mathrm{Rural\_Population}_j) \\ & + \beta_{6j}{}^{*}(\mathrm{PCP\_Density}_j) \end{aligned} \quad (1)$$

$$\begin{aligned}\text{CRD\_ At} - \text{RiskRate}_j = &\beta_{0j} + \beta_{1j}{}^*(\text{Smoking}_j) \\ &+ \beta_{2j}{}^*(\text{Alohol}) + \beta_{3j}{}^*(\text{LowIncome\_ Uninsured}_j) \\ &+ \beta_{4j}{}^*(\text{Population\_ Ratio}_j) + \beta_{5j}{}^*(\text{Unemployed}_j) \\ &+ \beta_{5j}{}^*(\text{Rural\_ Population}_j) + \beta_{6j}{}^*(\text{PCP\_ Density}_j) \end{aligned} \quad (2)$$

The predicted at-risk rate was used as an indicator for screening need (equation 2), which estimates the proportion of the state's population that is at risk for CRC. The predicted at-risk rate was sorted in ascending order and then divided into tertiles to stratify states by similar screening need. A relative predicted funding level was calculated for each state by taking the proportion of its predicted funding award (equation 1) out of the total predicted funding award for 25 states.

We then computed a vertical equity point by dividing the relative predicted funds (equation 1) by the proportion of its target population at risk for each state within each stratum, shown in equation 3. The vertical equity point measures a fair distribution of funds on the basis of the unscreened population for each state, after controlling for risk factors of CRC. We calculated vertical equity within each stratum to differentiate the level of funding for states with similar screening need relative to other states in their strata; each state was categorized as overequity, at-equity, or underequity to capture the historical dispersion of funding within each stratum. This provides a helpful way for grouping states to guide funding allocation.

$$\text{Vertical equity} = \frac{(\text{Relative predicted funds})}{(\text{Proportion of population at risk})} \quad (3)$$

where "relative predicted funds" is the proportion of the total average funds awarded per state controlling for population socioeconomic status and health behaviors, as well as state geography and health resources.

We defined the equity categories by using a *t*-distribution with an 80% confidence interval on the average of the vertical equity within each stratum. States defined as at-equity have a vertical equity point within the upper and lower limits of the 80% confidence interval, overequity states have a vertical equity point above the upper limit of the confidence interval, and underequity states have a vertical equity point below the lower limit of the confidence interval.

Results

The average relative funding and at-risk rate (proxy for screening need) in stratum 1 were 0.042 and 29.00%; stratum 2, 0.041 and 33.75%; and stratum 3, 0.037 and 38.01%. We found an inverse relationship between the predicted relative funding and screening need. For example, stratum 1 had the highest relative funding (0.042) but lowest screening needs (29.00%). The vertical equity point was relative to each stratum. Consequently, the equity labels are defined relative to each stratum. For example, in stratum 2, the vertical equity

ranged from 0.27 to 7.67, with an average of 2.92 and 80% confidence interval from 1.64 to 4.21. As a result, in stratum 2, 3 states had vertical equity points of 0.27, 0.64, and 1.01 (underequity), 3 states had vertical equity points of 1.86, 2.70, and 3.96 (at-equity), and 2 states had vertical equity points of 5.27 and 7.67 (overequity). Equity categories within each subsequent stratum were defined by using this method (Figure 1).

On the basis of our specific definition for measuring vertical equity, our results suggest that among states funded for the CRCCP, 11 states were underequity, 8 states were at-equity, and 6 were overequity. Figure 2 shows the distribution of the at-risk population on the equity point by strata illustrating a fairly linear, but inverse, relationship between the vertical equity point and the current size of the at-risk population. As the size of states' at-risk populations increases, vertical equity points are decreasing, which suggests that states with larger at-risk populations may have future levels of funding incrementally increased; conversely, states with smaller at-risk populations may have future levels of funding incrementally decreased to maintain a vertically equitable funding distribution.

Discussion

This case study illustrates the conceptual and methodological application of an equity measure for resource allocation of federal public health programs by using CDC's CRCCP as an example. The equity categorization of underequity, at-equity, and overequity guides decision makers of where funding adjustments can be made corresponding to health and program needs (ie, an equitable distribution based on the risk factors of the disease in question). The high number of states defined as under- or overequity could be due to a variety of reasons, such as (1) the nature of the standard, competitive application and objective review process by which CDC awards state grants; (2) a sufficient amount of funds available to the CRCCP to cover an at-equity distribution; or (3) a funding strategy that resulted in a horizontally equitable distribution when making funding decisions.

A measure of equity is not meant to be used by itself, but it should aid other funding strategies such as formula- or performance-based funding. Decision makers establish funding allocations on the basis of information given to them; thus, the more knowledgeable they are of the program and external influential factors to the program, the better able they are to make appropriate funding decisions with limited funds. Labeling states as overequity, at-equity, and underequity applies the principles of equity in a clear, practical, and straightforward way to advise decision makers of the status of funding levels on the basis of need in each state. This equity strategy used with another funding strategy supersedes one-sided decisions and can foster discussion among program leaders.

Because funding for public health programs may be limited or finite, the process of integrating vertical equity is a valuable tool for providing information to target funds where they may be needed most. This process supports effective use of public resources and addresses health disparities to improve equal opportunities to health.[41–45] The equity measure is meant to provide additional information that can support program planning and development.

When defining need across states, conceptualizing vertical equity is restricted by and could vary by the available scientific research and data, programmatic policy, conceptual reasoning, or value judgments. Even if a standard definition of need is established, the threshold for the appropriate amount of funds also varies and is built on subjectivity. Although including a measure of vertical equity can enhance the funding process, focusing solely on vertical equity may alter funding among states that are horizontally equitable by providing more funds to certain states to attain vertical equity.[27] Although there is a trade-off when integrating vertical equity, applying both vertical equity and horizontal equity may present a more comprehensive picture, so decision makers can be better informed about the potential resources necessary to achieve the maximum return on investment.

Continuous monitoring and evaluation are important for identifying gaps for improvements in the overall strategy to allocate funds to public health programs. The level of equity by state could alter as data change over time and new variables are integrated into the model. Evaluating this component of the funding strategy will increase the evidence base for its utility and help provide recommendations for improvement.

The major contribution of this study is to positively inform resource allocation strategy and to position this work within the broader literatures on the allocation of federal funding for public health programs. In addition, our methods incorporated population-adjusted burden of disease (ie, population at risk) in the funding strategy, which is required by Congress to be used as a significant criteria for awards, tracking measures, and evaluation of public health activities. Our study highlighted the importance of integrating vertical equity into funding strategies. This study defined equity related to the CRCCP specifically; however, the methodology or conceptual framework could be applied to almost any public health program allocating funds across states, such as breast and cervical cancer screening programs or a child immunization program, by adapting the variables to risk factors of that public health concern and adjusting the expected outcome that serves a specific target population. Applying this approach can increase transparency of the allocation of public funds and may improve the potential for programmatic impact among populations at risk. Although this approach is beneficial for public health funding strategies, decision makers may need to systemically choose variables that accurately reflect the specific program and not assume that additional funds directly result in better outcomes. It is important that each program research and evaluate equity characteristics that are most critical to funding and assess the current funding strategy before proceeding with establishing its own equity measures.

Some limitations in this study need to be acknowledged. First, some key variables were not available for the analysis. For example, CRC prevalence in CRCCP states was not available at the time of this analysis. Although the Surveillance, Epidemiology, and End Results Program of the National Cancer Institute estimated the number of cancer survivors for the United States, it did not provide estimates for all states funded through CRCCP; therefore, we were not able to estimate the true number of individuals at risk for developing the disease in CRCCP states. A true CRC prevalence rate would be a more appropriate indicator to observe the effects of the vertical equity factors because those who have already received a diagnosis of CRC would not be included in the target population. In addition, state-level measures, such as the structure of the health care system in a state and CRC clinical and

promotion costs, were unavailable. These factors may affect the efficiency of a program to reach and serve their target population, which in return may affect the resources each program needed to approach the same goal of an 80% screening rate. Given that this is a state-level analysis, and only 25 states were funded through CRCCP, we only included the most relevant and available factors in our model because of the sample size. Furthermore, we assumed that individuals older than 64 years used their Medicare insurance for CRC screenings, not considering other barriers to access beyond insurance coverage. Finally, results cannot be extrapolated to tribal organizations funded by CDC's CRCCP because of a lack of data specific to the tribe.

This study provided insights for several future areas of work. First, our model could be practically applied to the funding process of other public health programs. Second, our model could be improved by defining the threshold of base funding for each state, other than assuming all states started at zero or had the same baseline. Third, capacity assessment of the states with highest burden is needed because they often struggle to implement effective programs. Thus, better understanding their barriers other than just funding (eg, personnel, systematic) may help them get support to succeed and achieve sustainable development. Fourth, it is important to balance between efficiency and effectiveness in measuring the equity of funding strategies of public health programs. The interplay between equity and performance standards could be of interest. For example, a state categorized as underequity can be more resourceful with its funds and be a well-performing state, and vice versa, an overequity state can be a low performer.

Conclusion

In this study, we proposed a method for integrating vertical equity in the funding process for a federally funded public health program. There are many approaches to allocate funds to public health programs; however, applying equity to the funding strategy may provide more information to help guide the decision-making process. Targeting limited resources may help achieve health outcomes and attend to populations that are in greatest need. The methods used to integrate vertical equity in this case study could be applied in publicly funded programs to potentially minimize inequities and improve outcomes.

Acknowledgments

The authors thank Jessica King, Zachary Myles, and Thomas Richards, for their assistance in retrieving the data, and acknowledge Amy DeGroff, Janet Royalty, and Djenaba Joseph, for their guidance while writing the manuscript.

The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

References

1. Gostin LO, Powers M. What does social justice require for the public's health? Public health ethics and policy imperatives. Health Aff. 2006; 25(4):1053–1060.
2. Beauchamp, DE. Public health as social justice. In: Beauchamp, DE., Steinbock, B., editors. New Ethics for the Public's Health. New York, NY: Oxford University Press; 1999. p. 105-114.

3. Robert Wood Johnson Foundation. A New Way to Talk About the Social Determinants of Health. Princeton, NJ: Robert Wood Johnson Foundation; 2010.
4. Braveman P, Kumanyika S, Fielding J, et al. Health disparities and health equity: the issue is justice. Am J Public Health. 2011; 101(S1):149–155.
5. Polite BN, Dignam JJ, Olopade OI. Colorectal cancer model of disparities: understanding mortality differences in minority populations. J Clin Oncol. 2006; 24(14):2179–2187. [PubMed: 16682737]
6. Saldana-Ruiz N, Clouston SAP, Rubin MS, Colen CG, Link BG. Fundamental causes of colorectal cancer mortality in the United States: understanding the importance of socioeconomic status in creating inequality in mortality. Am J Public Health. 2013; 103:99–104. [PubMed: 23153135]
7. [Accessed January 30, 2014] Healthy People 2020. Healthy People Web site http://www.healthypeople.gov/2020/about/disparitiesAbout.aspx Published 2014
8. [Accessed January 15, 2014] CDC's National Program of Cancer Registries Cancer Surveillance System (NPCR-CSS) and the National Cancer Institute's Surveillance, Epidemiology, and End Results Program (SEER). http://nccd.cdc.gov/DCPCINCA. Published November 2013
9. Braveman P. Health disparities and health equity: concepts and measurement. Ann Rev Public Health. 2006; 27:167–194. [PubMed: 16533114]
10. Braveman P. What is health equity: and how does a life-course approach take us further toward it? Matern Child Health J. 2014; 18:366–372. [PubMed: 23397099]
11. Buehler JW, Holtgrave DR. Who gets how much: funding formulas in federal public health programs. J Public Health Manag Pract. 2007; 13(2):151–155. [PubMed: 17299318]
12. DeGroff A, Royalty J, Howe W, et al. When performance management works: a study of the National Breast and Cervical Cancer Detection Program. Cancer. 2014; 120(16)(suppl):2566–2574. [PubMed: 25099899]
13. Lasry A, Sansom SL, Hicks KA, Uzunangelov V. A model for allocating CDC's HIV prevention resources in the United States. Health Care Manag Sci. 2011; 14(1):115–124. [PubMed: 21184183]
14. Ogden L, Sellers K, Sammartino C, Buehler JW, Bernet PM. Funding formulas for public health allocations: federal and state strategies. J Public Health Manag Pract. 2012; 18(4):309–316. [PubMed: 22635184]
15. Buehler JW, Holtgrave DR. Challenges in defining an optimal approach to formula-based allocations of public health funds in the United States. BMC Public Health. 2007; 7:44. [PubMed: 17394645]
16. Joseph D, DeGroff AS, Hayes NS, Wong FL, Plescia M. The colorectal cancer control program: partnering to increase population level screening. Gastrointest Endosc. 2011; 73(3):429–434. [PubMed: 21353839]
17. US Preventive Services Task Force. Screening for colorectal cancer: U.S. Preventive Services Task Force Recommendation. Ann Intern Med. 2008; 149:627–637. [PubMed: 18838716]
18. Mooney G. Vertical equity in health care resource allocation. Health Care Anal. 2000; 8:203–215. [PubMed: 11186022]
19. Leclerc, PD., McLay, LA., Mayorga, ME. Modeling Equity for Allocating Public Resources. New York, NY: Springer; 2012.
20. Repetti JR, Ring DM. Horizontal equity revisited. Fla Tax Rev. 2013; 13(3):135–155.
21. Steuerle, CE. And Equal (Tax) Justice for All?. Washington, DC: Tax Policy Center, Urban Institute and Brookings Institution; http://www.urban.org/sites/default/files/steuerle-excerpt.pdf. Published November 1, 2002 [Accessed June 6, 2013]
22. Rodriguez GM. Vertical equity in school finance and the potential for increasing school responsiveness to student and staff needs. Peabody J Educ. 2004; 79(3):7–30.
23. Berne, R., Stiefel, L. Concepts of school finance equity: 1970 to the present. In: Ladd, HF.Chalk, R., Hansen, J., editors. Equity and Adequacy in Education Finance: Issues and Perspectives. Washington, DC: National Academies Press; 1999. p. 7-33.
24. Vesely RS, Crampton FE. An assessment of vertical equity in four states: addressing risk factors in education funding formulas. J Educ Finance. 2004; 30(2):111–122.

25. Berne R, Stiefel L. Concepts of equity and their relationship to state school finance plans. J Educ Finance. 1979; 5(2):109–132.
26. Toutkoushian RK, Michael RS. An alternative approach to measuring horizontal and vertical equity in school financing. J Educ Finance. 2007; 32(4):395–421.
27. Behavioral Risk Factor Surveillance System. [Accessed December 1, 2013] BRFSS Web site. http://www.cdc.gov/brfss. Published 2010
28. Botteri E, Iodice S, Bagnardi V, Raimondi S, Lowenfels AB, Maisonneuve P. Smoking and colorectal cancer: a meta-analysis. JAMA. 2008; 300(23):2765–2778. [PubMed: 19088354]
29. Giovannucci E. An updated review of the epidemiological evidence that cigarette smoking increases risk of colorectal cancer. Cancer Epidemiol Biomark Prev. 2001; 10:725–731.
30. Marchand LL, Wilkens LR, Kolonel LN. Associations of sedentary lifestyle, obesity, smoking, alcohol use, and diabetes with the risk of colorectal cancer. Cancer Res. 1997; 57:4787–4794. [PubMed: 9354440]
31. Ayanian JZ, Weissman JS, Schneider EC, Ginsburg JA, Zaslavsky AM. Unmet health needs of uninsured adults in the United States. JAMA. 2000; 284(6):2061–2069. [PubMed: 11042754]
32. Rametta S, Grosso G, Galvano F, et al. Social disparities, health risk behaviors, and cancer. BMC Surg. 2013; 13(2):S17. [PubMed: 24267900]
33. Lantz PM, Pritchard A. Socioeconomic indicators that matter for population health. Prev Chronic Dis. 2010; 7(4):1–7.
34. Shavers VL. Measurement of socioeconomic status in health disparities research. J Natl Med Assoc. 2007; 99(9):1013–1023. [PubMed: 17913111]
35. Arcury TA, Gesler WM, Preisser JS, Sherman J, Spencer J, Perin J. The effects of geography and spatial behavior on health care utilization among the residents of a rural region. Health Serv Res. 2005; 40(1):135–156. [PubMed: 15663706]
36. Curtis S, Jones IR. Is there a place for geography in the analysis of health inequality? Sociol Health Illness. 1998; 20(5):645–672.
37. Ananthakrishnan AN, Hoffman RG, Saeian K. Higher physician density is associated with lower incidence of late-stage colorectal cancer. J Intern Med. 2009; 25(11):1164–1171.
38. Benarroch-Gampel J, Sheffield KM, Lin Y, Fang Y, Goodwin JS, Riall TS. Colonoscopist and primary care physician supply and disparities in colorectal cancer screening. Health Serv Res. 2012; 47(3):1137–1157. [PubMed: 22150580]
39. Soneji S, Armstrong K, Asch DA. Socioeconomic and physician supply determinants of racial disparities in colorectal cancer screening. J Oncol Pract. 2012; 8(5):125–134.
40. Asada Y. A framework for measuring health inequity. J Epidemiol Community Health. 2005; 59:700–705. [PubMed: 16020649]
41. Thomas SB, Quinn SC, Butler J, Fryer CS, Garza MA. Toward a fourth generation of disparities research to achieve health equity. Ann Rev Public Health. 2011; 32:399–416. [PubMed: 21219164]
42. World Health Organization. Priorities for Research on Equity and Health: Implications for Global and National Priority Setting and the Role of WHO to Take the Health Equity Research Agenda Forward. Final Report. Task Force on Research Priorities for Equity in Health. Geneva, Switzerland: World Health Organization; http://www.who.int/social_determinants/implementation/Thefinalreportnovember2010.pdf. Published November 2010 [Accessed December 30, 2013]
43. Plescia M, Richardson L, Joseph D. New roles for public health in cancer screening. CA Cancer J Clin. 2012; 62(4):217–219. [PubMed: 22573193]
44. Frieden TR. Six components necessary for effective public health program implementation. Am J Public Health. 2014; 104(1):17–22. [PubMed: 24228653]

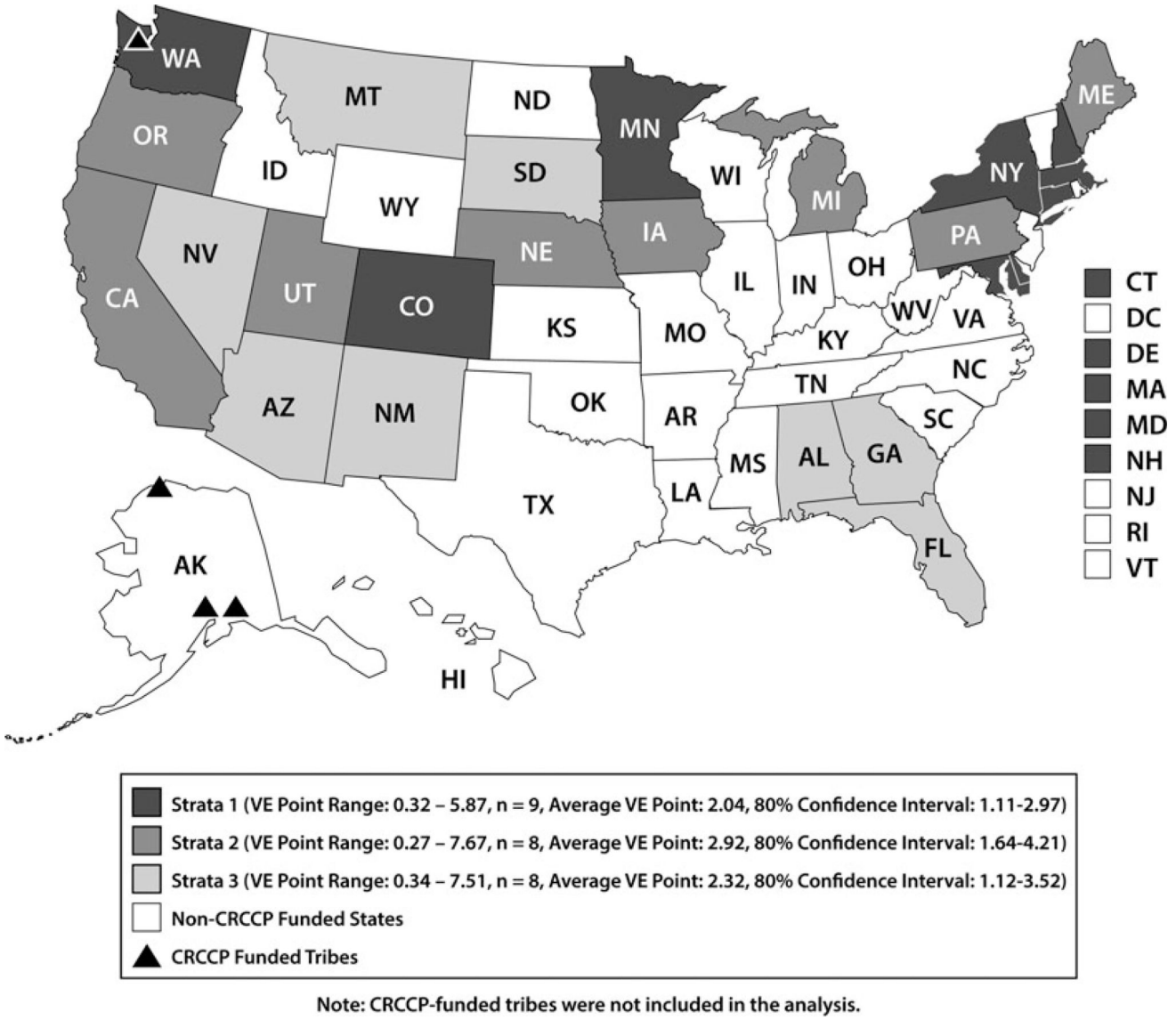

FIGURE 1. State Stratifications of CRCCP States by Measures of VE

Abbreviations: CRCCP, Colorectal Cancer Control Program; VE, vertical equity.

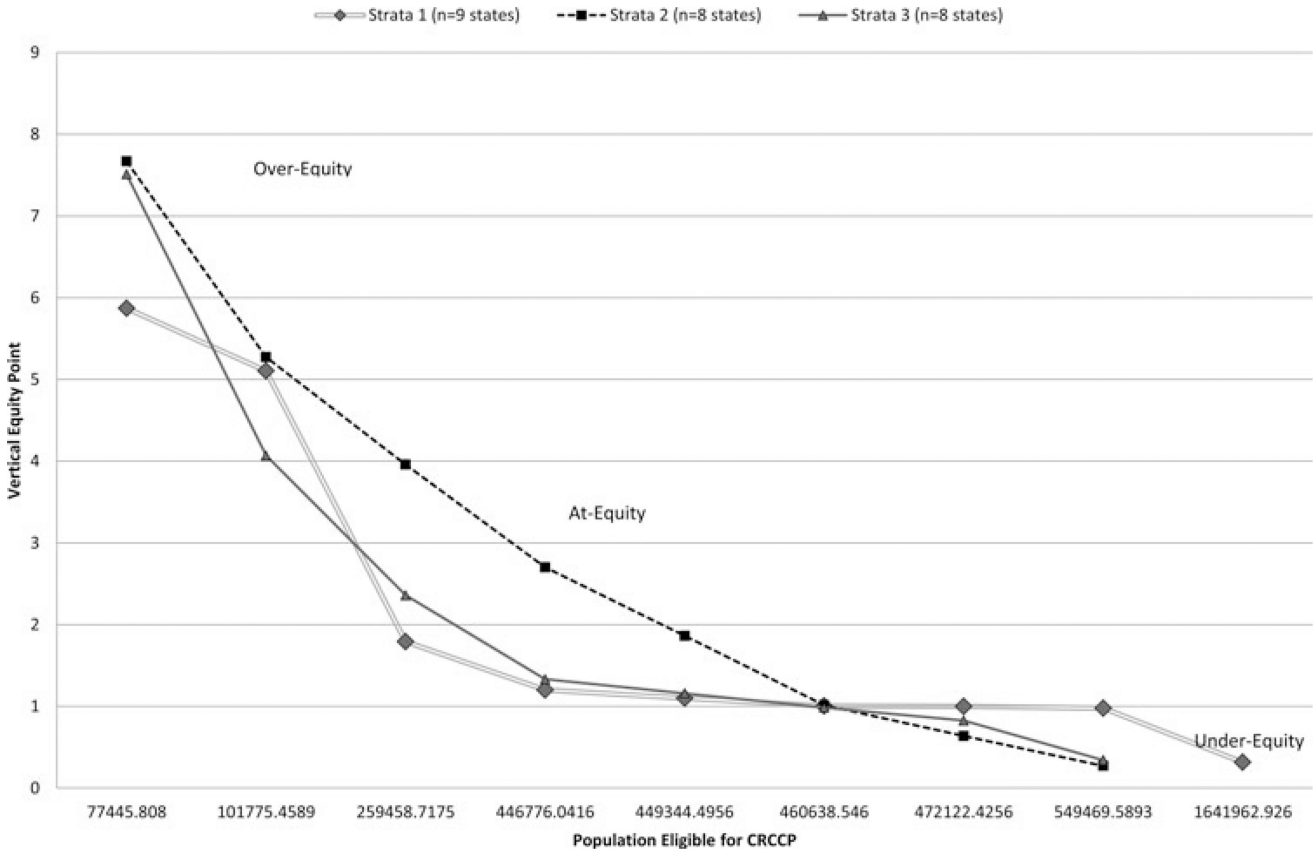

FIGURE 2. Distribution of Population Eligible for CRCCP and Vertical Equity Point by Stratum
Abbreviation: CRCCP, Colorectal Cancer Control Program.

TABLE

Variables Used in Regression Analyses

Variable Name	Definition	Descriptive Statistics	Source
Dependent variables			
CRC_Unscreened Rate	Percentage of individuals (aged 50–75 y) who have not had a colonoscopy in the last 10 y and/or flexible sigmoidoscopy in last 5 y with FOBT in last 3 y or FOBT in last year	Mean = 33.4% Min = 24.8% Max = 42.5% SD = 5.3	2011 BRFSS
Average Award	CRCCP average state funding awarded for the period 2009–2013	Mean = $894 015 Min = $553 252 Max = $1 380 181 SD = 151 323	CDC's CRCCP
Explanatory variables			
Smoking	Percentage of adults who currently smoke cigarettes every day or some days	Mean = 14.4% Min = 8.9% Max = 19.4% SD = 0.025	2011 BRFSS
Alcohol	Percentage of adults who are excessive drinkers	Mean = 2.7% Min = 1.4% Max = 4.6% SD = 0.007	2011 BRFSS
LowIncome_ Uninsured	Percentage of adults who are below 250% of the federal poverty line and uninsured	Mean = 7.5% Min = 2.2% Max = 12.4% SD = 0.027	US Census Bureau 2011 Small Area Health Insurance Estimates
Unemployed	Percentage of adults who are unemployed	Mean = 8.0% Min = 4.2% Max = 11.4% SD = 0.020	2011 BRFSS
Population_Ratio	Proportion of persons (aged 50–75 y) eligible for the CRCCP who are not up-to-date with screening out of the total population in the same age range	Mean = 0.04 Min = 0.005 Max = 0.20 SD = 0.045	2011 BRFSS—numerator US Census Bureau 2011 population estimates—denominator
Rural_Population	Percentage of the population residing in rural counties	Mean = 22.6% Min = 0.41% Max = 64.8% SD = 0.172	US Census Bureau 2011 population estimates National Center for Health Statistics Rural Urban County Codes
PCP_Density	Number of primary care physicians per 100 000 in rural counties	Mean = 50.9 Min = 33.1 Max = 94.3 SD = 15.2	Health Services and Resources Administration 2010 Area Health Resources File

Abbreviations: BRFSS, Behavioral Risk Factor Surveillance System; CRCCP, Colorectal Cancer Control Program; FOBT, fecal occult blood test.