SOCIOECONOMIC FACTORS AFFECTING BREAST CANCER SCREENING

A Research Paper submitted to the Department of Engineering and Society
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Biomedical Engineering

By

Emma Imbarlina

March 30, 2023

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed: Emma Imbarlina

ADVISOR
Catherine D. Baritaud, Department of Engineering and Society

ADDRESSING BREAST CANCER THROUGH TECHNOLOGY AND SOCIETY

Breast cancer (BrCa) is the leading cause of cancer mortality in women, and the majority of these deaths can be attributed to metastasis, the development of malignant tumors distal to the original tumor site (Scully et al., 2012, p.311). As is the case with most cancer types, the disease is often detected too late to respond to less aggressive treatment options, and doctors struggle to control tumor borders. Despite being the second most frequent cause of brain metastasis, a diagnosis associated with reduced life expectancies and overall poor prognosis, late-stage BrCa has been largely underinvestigated and current screening practice for BrCa appears insufficient to prevent late diagnosis. Thus, both early detection strategies and characterization of BrCa progression prove essential in improving overall survival rate. Due to the tendency of BrCa to progress and metastasize quickly, early stage detection as well as development of improved treatment for late stage cancer types offer hope for the reduction of mortality rates in women.

The technical project and tightly coupled STS research topic at hand provide insights for both clinical and social approaches to this issue. Alarmingly, five-year survival rates for BrCa drop from 100% if diagnosed at stage I to 26% if diagnosed at stage IV (Loh et al., 2019, p.4940). To address the current difficulty in effectively treating late stage BrCa, the technical project aims to design a combinatorial treatment paradigm involving focal therpay moldulation of extracellular vesicle release in vitro. In leveraging informative biomarkers indicating cancer progression, the objective is to develop a system for targeted drug therapy dependent on metastatic capacity and hormone receptor status which relies upon modulation by focal therapies. In evaluating the ability of focused ultrasound and x-ray irradiation to increase the availability of tumor-associated biomarkers known to alter the tumor microenvironment and allow for cancer growth and metastasis, the in vitro model may be used to inform minimally invasive designs for

diagnosis, surveillance, and treatment of BrCa.

The mitigation of BrCa mortality intersects with society through revelation that economic disparities may be responsible for the continued lack of proper screening. This contributes to a lack of early detection for less aggressive cancer forms which prove more responsive to treatment. Therefore, in light of President Biden's new Advanced Research Projects Agency for Health (ARPA-H), an organization formed to develop improvements in healthcare through high-impact translational research, the paired STS research paper suggests a remodeled universal screening program which includes testing of current diagnostic standards, a mandatory battery of updated testing procedures, and educational resources for all women in the United States (Advanced Research Projects Agency for Health, n.d.). These efforts may increase early stage detection rates for BrCa and transcend socioeconomic disparities, as demonstrated through a linear Actor Network theory (ANT) model, a conceptual framework which emphasizes the relationships between human and non-human actors and their mutually contributions to the sociotechnical problem at hand (Law & Callon, 1988, p.295).

Current gaps in prognostication and late-stage treatment of BrCa have lead to not only reduced survival rates among women, but also poor quality of life in those diagnosed with the disease. Therefore, it is important to identify solutions for these gaps and develop strategies for both early detection and treatment of late-stage BrCa types. The technical project and tightly coupled STS research topic proposed provide insight into options for both via *in vitro* studies revolving around EVs as potential biomarkers and the prospect of a mandated set of screening procedures and educational resources which transcend socioeconomic (SES) disparities. Clearly, the troublesome statistics which headline discussion of BrCa in women are held captive to both

underlying biological and societal complications. Though the sheer number of barriers to proper care seems overwhelming, hope resides in the acknowledgement that both social and technical factors intertwine to create both problem and solution. In this way, the separate projects outlined outlined are indeed paired in that the overall goal of reduction in mortality and morbidity rates for women with breast cancer relies on both approaches for success.

SOCIOECONOMIC FACTORS AND BREAST CANCER MORTALITY IN WOMEN

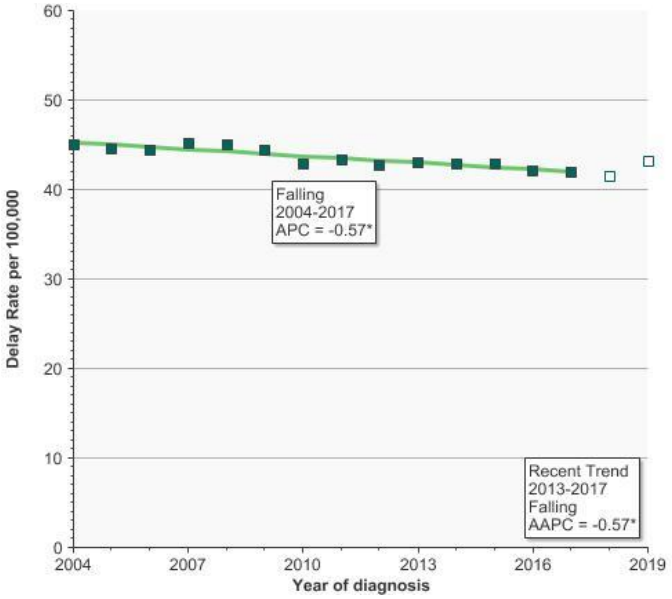

Figure 1: Rates of new cases of late stage female breast cancer, delay-adjusted incidence. In 2004-2019, the delay in late detection rate per 100,000 females has decreased minimally.
(Stage at Diagnosis | Cancer Trends Progress Report, 2022)

Despite advances in oncology and standard screening programs in the United States, the late-stage BrCa detection rate has not decreased much since the early 2000s, as depicted in Figure 1 (Stage at Diagnosis | Cancer Trends Progress Report, 2022). The continued lack of proper early detection may result from differences in screening practice between socioeconomic groups. Sprague et al. (2011) suggest that economic disparities are possibly responsible for the continued lack of proper screening, as survival rates among women diagnosed with BrCa are lower for those with a lower SES (p. 1544) . Lack of education, low income, and living in an area of low community-level education or income may all constitute such status and, in part, contribute to lower BrCa survival rates through insufficient use of screening mammography and subsequent late-stage diagnosis.

Thus, it is imperative to address the inferior healthcare afforded to those of lower SES in order to improve overall BrCa mortality rate for United States women.

UNITED STATES HEALTH INSURANCE AND INCONSISTENT POLICIES

The Introduction of the Affordable Care Act

Most notable of all factors affecting BrCa screening differences across socioeconimc classes, health insurance proves a more complex problem than it may appear at surface level. In 2010, the Affordable Care Act (ACA) expanded Medicaid to cover all adults below the Federal Poverty Line and allow a national mandate instructing all Americans to purchase some form of health insurance. A landmark Supreme Court decision in 2012 offered further assistance to achieve this goal, and 32 states opted to further expand Medicaid. Figure 2 color codes expansion and non-expansion states to illustrate this divide. Ideally, ACA Medicaid expansion aimed to increase BrCa screening among women in the United States, as the mandate theoretically increased access to healthcare for lower SES groups that may have previously been neglected.

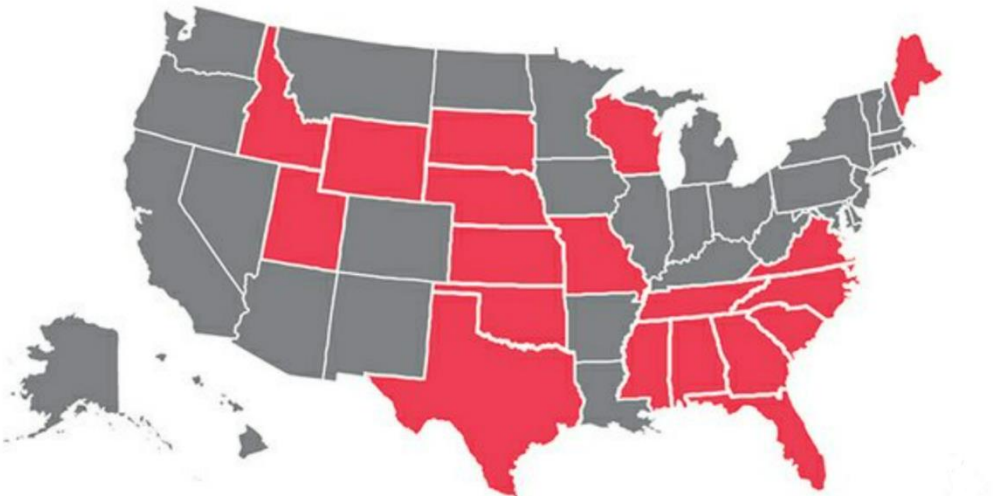

Figure 2: United States map of 2012 ACA Medicaid expansion. In 2012, only 32 States (including Washington, D.C.) opted to expand public insurance coverage benefits, allowing for healthcare disparities between these states and the 19 states which did not. (Study: Without Medicaid expansion, poor forgo medical care, n.d.)

Seizing the unique opportunity to determine governmental influence on rate and scope of BrCa screening as a result of insurance expansion, Toyoda et al. (2020) found that states which accepted the Supreme Court's offer saw higher rates of BrCa mammogram screening than the 19 states that did not adopt the new policies (p.780). As Medicaid primarily benefits lower SES individuals unable to afford public health insurance policies, it is logical to attribute the observed screening increase to improved healthcare for this group. In this way, providing a form of public health insurance positively affects BrCa screening of women in the United States on some level. However, this cancer type is still the leading cause of cancer mortality in women, which prompts examination of further mechanisms for early detection.

Inequality between Public and Private Insurance Policies

Although ACA Medicaid expansion led to an increased rate of BrCa screening among United States women, inequalities between public and private health insurance remain a legitimate concern in regards to healthcare access for lower-income individuals, a problem that may be contributing to continued late-stage detection. Notably, individuals with private insurance demonstrate lower rates of stage IV diagnosis while uninsured individuals and those with Medicaid demonstrate comparably higher rates of late detection (Ko et al,. 2020, p.388). Confirming that statistic, other studies show that those with Medicaid have significantly worse access than Americans with private health insurance, a fact largely attributed to low reimbursement rates for physicians and which arguably limits BrCa screening and early detection (Dayaratna, 2012, p. 2741).

ACA Medicaid expansion, a program which seemingly increased healthcare access for lower SES individuals, may have contributed to the observed differences in the intersection between insurance and healthcare benefits. As the expansion lowered premiums in the private

marketplace of non-expansion states, increasing access to care for those with more favorable SES, it follows that the lack of such coverage among lower SES groups exacerbates barriers to care which potentiates a lack of adequate BrCa screening , associated late detection, and poor patient outcomes (Toyoda et al., 2020, p.781). Despite the ACA, about 27 million Americans remain uninsured, which certainly contributes to the ongoing disparity affecting lower SES women (Dickman, 2017, p. 1431). However, the insurance differences discussed emphasize the fact that nationwide expansion of Medicaid may not be sufficient and provide support for remodeling the Medicaid program to actually benefit lower-class individuals.

INADEQUATE PRACTICE RESULTS FROM RELIANCE ON STANDARDS

Understanding Cancer Standards in Healthcare

In addition to insurance-based socioeconmic disparities, current screening standards largely contribute to insufficient early detection of BrCa. As a prominent and emotionally-charged disease in today's world, cancer has been studied for years in an effort to determine new treatment options and find a "cure." Of course, this means that doctors and researchers alike have agreed upon standards of care appropriate for basic cancer treatment. These standards are adhered to strictly amidst experimental efforts in the research realm and the prospect of ending cancer, a practice that has contributed to neglect in continuous evaluation and updating of diagnostic and treatment measures. For example, radiation post-surgery for women with BrCa is a common treatment prescribed by oncologists, yet new studies suggest that the survival rate for those who receive radiation and those who do not are relatively equal (Abbot, 2023, p. A1). In that case, subjecting women to further aggressive treatment, simply in adherence to standards, may be unethical. In terms of the socioeconomic problem at hand, neglecting to update standards to accommodate lower SES individuals may leave screening attendance subject to a multitude of

competing factors. Studies find a higher rate of primary care non-attendance in lower SES individuals due to familial responsibilities, employment conflicts, and lack of transportation (Chapman et al., 2022, p. 6). These boundaries to receiving proper BrCa screening may be alleviated through development of diagnostic procedures which take less of a toll on lower SES women in terms of time and effort. In this way, cancer standards, including current screening procedures, may require re-evaluation for maximum patient benefit and efficacy.

The Pitfalls of Mammography

Mammography, a type of X-ray scan used to identify tumors in breasts, has been the golden standard for BrCa screening since the 1980s, marketed as a strategy for early diagnosis and improved patient outcomes. Yet the incidence rates for late-stage BrCa have remained stable since that time (Autier & Boniol, 2018, p. 34). The role of mammograms as a diagnostic method is highly debated, but it is clear that the practice may not be contributing significantly to early detection. The potential for multiple scans increases radiation dose as well as associated risk to individuals, and overdiagnosis is realtively common, discouraging women from the screening process in general (Heywang-Köbrunner et al., 2011, p. 205).

For women of lower SES, X-ray scans are an unnecessary expense with seemingly little benefit, both financially and in terms of time efficiency. Because receiving a mammogram requires women to travel to a clinical setting which houses appropriate equipment, regardless of childcare or employment responsibilites, there is a perceived “hassle” associated with screening. Seeing as many women of lower SES status may require funds to procure a means of transportation while forgoing a day’s worth of income, it is easy to understand the aversion to medical testing perceived as optional. Overall, studies have demonstrated that screening attendence varies inversely with the number of perceived barriers to attendence (VanDyke &

Shell, 2017, p. 351). As women of lower SES status often see the inflexibility of appointments as a hassle interfereing with their busy schedules, this group often perceives barriers to screening as outweighing the risks associated with neglecting mammogram appointments (Chapman et al., 2022, p. 9). Thus, in an effort to reduce BrCa mortality in women through increased screening and earlier detection, the emphasis on mammography may be best placed on a different, less costly technique or, at the very least, requires re-evaluation.

NEGATIVE ATTITUDES BECOME BOUNDARIES TO HEALTHCARE

Though current health insurance practice certainly contributes to the lack of adequate BrCa screening which perpetuates late detection and high morbidity rate, there is an additional factor affecting lower SES women specifically. In analyzing the association between SES and BrCa survival, Sprague et.al found the lowest survival rates among the least educated women (2011, pg. 1547). One possible explanation for this finding is the tendency of lower SES groups towards negative attitudes and a general lack of hopefulness when presented with treatment options, as these groups tend to experience inferior access to healthcare due to the aforementioned inequities between public and private insurance (Quaife et al., 2015, p.256). This pessimistic belief system may partially explain continued late stage diagnoses in these groups, as less faith in medical intervention logically imbues hesitancy to seek help from medical professionals.

Fatalism Path Modeling

Fatalism is "the perception that events and/or health issues are out of individual control," a definition which may describe lower SES women who automatically assume the outcome of a BrCa diagnosis will be negative (Beeken et al., 2011, p. 2127). Beeken et al. (2011), in examination of the potential that SES disparities in early detection attitudes may partially explain

SES differences in fatalism, find that there is a direct relationship between SES and avoidance of cancer-related information, fear of reporting symptoms, and perceived value of early detection, as depicted in Figure 3. In contributing to later-stage detection of BrCa and the increased mortality and morbidity rates resulting from cancers which do not respond readily to treatment efforts, this relationship may provide insights for progress. Given the negative belief system observed in lower SES individuals, it may be necessary to supplement federal policy with social reform efforts to provide a reasonable starting point in addressing the lack of early detection among women with BrCa.

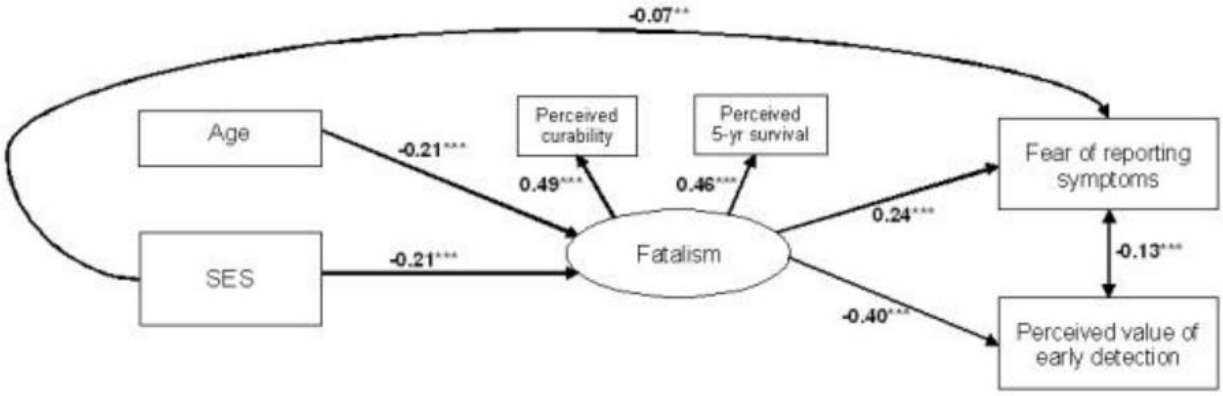

Figure 3: The Relationship between Fatalism and Attitude. Fatalism represents a direct relationship to SES, age, perceived curability, perceived 5-year survival, fear of reporting symptoms, and perceived value of early detection. Each of these factors contributes to the negative attitudes found in women of lower SES groups. (Beeken, 2011, p. 2130)

EXPLAINING BREAST CANCER REDUCTION IN TERMS OF SES DISPARITIES

In light of the relationships between each of the proposed focus points, a linear Actor Network Theory (ANT) most accurately describes the current relationships between relevant groups which perpetuates poor patient outcomes for women with BrCa, as each "actor," whether

social or technical, interacts with the next to ultimately result in high mortality and morbidity rates for women diagnosed (Law & Callon, 1988, p.295). Figure 4 depicts such a model, clearly representing the way in which partial expansion of ACA Medicaid presents several barriers to improve overall prognosis in women of lower SES groups.

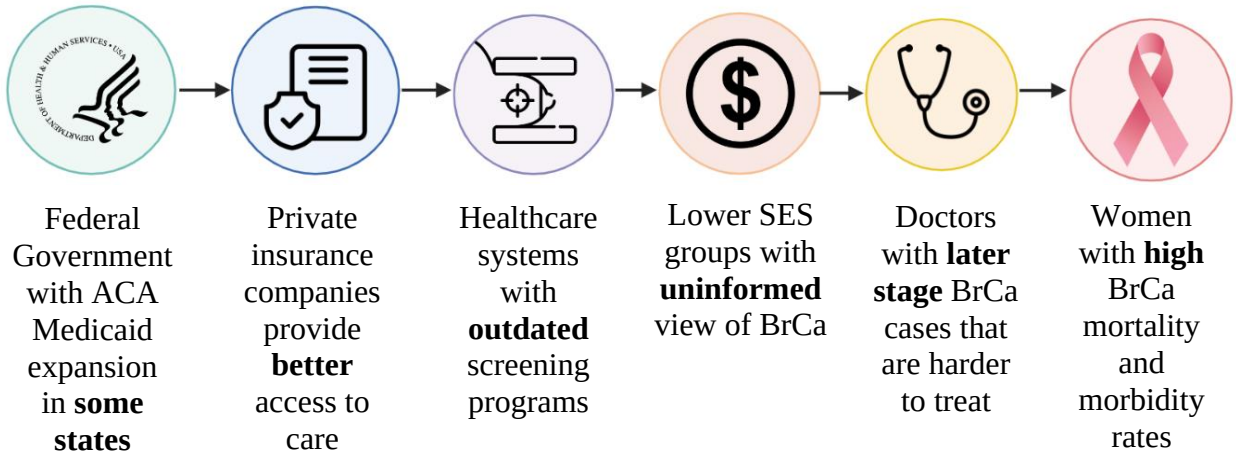

Figure 4: ANT model for lower SES women diagnosed with BrCa. ACA Medicaid introduction by the government intended to increase access to care but acted on other social forces to create poor patient outcomes in women with BrCa via a handoff model. (Adapted by Imbarlina (2022) from Carlson, 2009)

NEW PROGRAM HAS POTENTIAL TO MINIMIZE EFFECT OF SES DISPARITIES

President Biden's new program, ARPA-H, supports development of important research for scientific breakthroughs impacting healthcare, spirited by an initiative for collaboration and overall patient care (Advanced Research Projects Agency for Health, n.d.). In its governmental role and goal to improve overall patient outcomes through study and implementation of findings, the organization presents an ideal opportunity for re-evaluated BrCa screening practice. Based on all previously discussed factors surrounding BrCa screening and associated SES disparities, altering the first four focus points of the current linear ANT theory model may drastically change outcomes represented by the last two groups. As shown in Figure 5, progress for reduced BrCa

mortality and morbidity rates relies upon acknowledgement of SES factors. President Biden's new program, ARPA-H, supports development of important research for scientific breakthroughs impacting healthcare, spirited by an initiative for collaboration and overall patient care (Advanced Research Projects Agency for Health, n.d.). In its governmental role and goal to improve overall patient outcomes through study and implementation of findings, the organization presents an ideal opportunity for re-evaluated BrCa screening practice. Based on all previously discussed factors surrounding BrCa screening and associated SES disparities, altering the first four focus points of the current linear ANT theory model may drastically change outcomes represented by the last two groups. As shown in Figure 5, progress for reduced BrCa mortality and morbidity rates relies upon acknowledgement of SES factors.

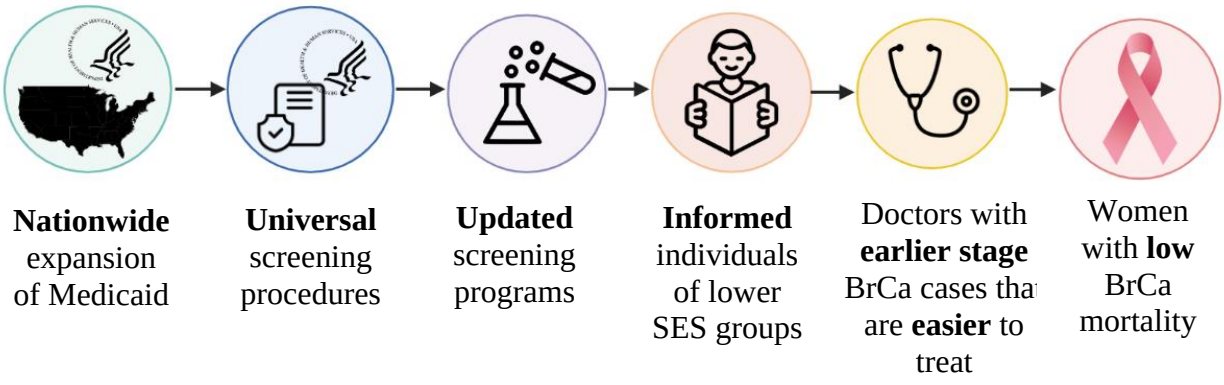

Figure 5: Envisioned linear ANT model for lower SES women diagnosed with BrCa. Social and political factors act to change the climate of BrCa patient outcomes, beginning with a nationwide expansion of ACA Medicaid. (Adapted by Imbarlina (2022) from Carlson, 2009)

ADDRESSING FACTORS AFFECTING LATE DETECTION

Nationwide Expansion of Medicaid

Clearly, ACA Medicaid expansion, while certainly offering hope for government policy as a viable means of progress, did not address concerning BrCa statistics in full. The Supreme Court ruling and subsequent Medicaid expansion found some success in managing late detection

of BrCa, seeing as states which accepted the expansion in 2012 saw higher rates of BrCa mammogram screening than those that did not (Toyoda et al., 2020, p. 780). However, 19 states did not adopt the new policy, allowing for many Americans to remain uninsured. The addition of wide-spread public health insurance also had a significant effect on private health insurance, lowering premiums of private insurance companies in non-expansion states and increasing access to care for individuals who can afford such coverage. Thus, to ensure appropriate access for all American women, thereby increasing chances of early BrCa detection, ARPA-H should expand Medicaid to all states.

Universal screening procedures

Though expanding Medicaid nationwide may allow greater access to care for previously uninsured individuals, the obvious differences in public and private health policies still present a challenge for lower SES women in receiving proper BrCa screening. In this way, it is of the utmost importance to close the gap between insurance offerings and create standards for care independent of policy source. Dickman, et al. (2017) state that "to achieve health-care equality, a non-market financing scheme that treats health care as a human right is essential" (p. 1431). Of course, to achieve such a state may be nearly impossible under the tenets of the United States free market, but certainly enforced standards for insurance offerings could allow for sufficient access to healthcare. For product development, there is an International Organization (ISO) which details general technological qualities for adherence during engineering design (About us, n.d.). A similar governmental strategy for insurance policies may allow for market diversity and preservation of the American dream whilst simultaneously ensuring that all women have adequate access to reliable BrCa screening.

Updated Screening Procedures

As cancer research evolves, it is important to establish new screening procedures which may prove more affordable and timely than mammograms. While such imaging techniques are regarded as the golden standard for BrCa screening, there are certainly many drawbacks, including cost and travel for appointments. There are several current research initiatives that address these problems while providing a more reliable diagnosis, including liquid biopsy (Marrugo-Ramírez et al., 2018, p. 28). Liquid biopsy is a minimally invasive and repeatable strategy which leverages biomarkers in blood samples. Although there is further research required to introduce the practice clinically, it represents one such technique presenting a legitimate solution to the disadvantages of mammography. In this way, ARPA-H should continually monitor research initiatives towards novel cancer screening initiatives while simultaneously assessing current screening programs and updating them when necessary.

Learning Screening Programs

As previously established, current cancer care standards may be outdated and ill-suited for lower SES groups, including the use of mammography for BrCa screening. Though screening is known to both increase early detection rates and allow for possible medical complications, the balance between benefits and risks is often poorly understood. Prescription drugs do not enter the market without extensive testing in randomized control trials (RCTs), yet the same requirements do not exist for screening tests, and magnifying the issue, there is a lack of worldwide consensus regarding test intervals and positive thresholds for each cancer type (Kalager & Bretthauer, 2020, p.143). These inconsistencies cause a high incidence of overdiagnosis and neglect of psychological traumas associated with subsequent treatments. To combat this worldwide phenomenon, Kalager & Bretthauer (2020) propose the idea of a learning screening program

which continuously and systematically evaluates testing procedures to determine which is most effective while simultaneously ensuring that the benefits outweigh the risks (p. 143).

Implementation of such a program could allow for continual monitoring and evaluation of standard practice and development of universal testing procedures without disruption of current measures towards increased early detection of cancers, as they take advantage of pre-existing screening programs and ask patients for permission to randomize different testing procedures, intervals, or thresholds to determine the optimal screening mechanism which reduces mortality while controlling for overdiagnosis. Finland is one success story, boasting a 2020 learning program completed in evaluation of standard colon cancer screening as proof that such a program allows for testing procedures to evolve with disease (Kalager & Bretthauer, 2020, p.144).

In evaluating such characteristics of current BrCa screening through mammograms, a learning program may lead to discoveries which alleviate time or transportation conflicts for lower SES women and determine the efficacy of updating standard screening practice to include new mechanisms such as liquid biopsy. As learning screening may be easily funded through public health programs for cost efficiencies, they are best suited for government health agencies, like ARPA-H, to better monitor widespread cancer testing and to take responsibility for ensuring appropriate improvements to the current standard.

Access to Educational Resources

Given findings that negative attitudes surrounding cancer diagnosis may be affecting lower SES populations, it may be necessary to supplement federal policy with social reform efforts to provide a reasonable starting point in addressing the lack of early detection among women with BrCa. To this point, success in self-health management via technological

development suggests a viable alternative for promoting increased BrCa screening and combating negative beliefs held by lower SES groups, given modern demonstrations of such practice as particularly motivating for hormonal health (Ford et al., 2021, p.50-52). Mobile applications which encourage women to track their hormonal cycles provide ample opportunity for organizations like ARPA-H to inform women of the benefits to early detection and promote regular screening among select populations. Integrating education into the constantly advancing climate of technology-driven society holds potential to overcome the less political and economic limitations to early detection.

A SOCIOTECHNICAL SOLUTION TO HEALTHCARE DISPARITIES

Healthcare between socioeconomic classes is not equal, and effects of this inequality are demonstrated by the continued lack of proper BrCa screening in women. The responsibility of engineers in developing regulations, standards, and technologies is first and foremost to put human health above personal gain, especially in the medical field. The varying factors causing BrCa screening disparities prove that the role of the engineer is not solely to create novel products and services, but also to analyze and understand the social consequences of one's actions. Of course, it may prove impossible for engineers to tackle both technical and social problems to the same degree, however it is of the utmost importance that those involved with decelopment of technological systems, especially those which are medical in nature, recognize the role of society and incorporate appropriate ethical considerations.

In accordance with the complex nature of economic, political, and social powers surrounding BrCa screening and subsequent reduction of mortality rates for women, this investigation suggests support from ARPA-H in expanding public insurance coverage across the nation, providing universal insurance standards between this public policy and private

companies, enacting learning screening programs to assess the efficacy of mammograms and potentially replace this golden standard with a superior alternative, and offering educational resources to ensure emphasis on early diagnosis and minimize negative attitudes surrounding BrCa diagnosis. Though efforts to expand government intervention and equalize insurance in the American free marketplace appear unlikely, this recommendation suggests a flaw in the current state of United States healthcare, and change may prove a requirement to address current socioeconomic disparities in full.

REFERENCES

Abbott, B. (2023, February 16). Breast-cancer treatment rethought. *The Wall Street Journal*, A1.

About us. (n.d.). *ISO*. Retrieved March 1, 2023, from https://www.iso.org/about-us.html

Advanced Research Projects Agency for Health (ARPA-H). (n.d.). The White House. https://www.whitehouse.gov/ostp/advanced-research-projects-agency-for-health-arpa-h/

Autier, P., & Boniol, M. (2018). Mammography screening: A major issue in medicine. *European Journal of Cancer*, 90, 34–62. https://doi.org/10.1016/j.ejca.2017.11.002

Beeken, R. J., Simon, A. E., von Wagner, C., Whitaker, K. L., & Wardle, J. (2011). Cancer fatalism: Deterring early presentation and increasing social inequalities? *Cancer Epidemiology, Biomarkers & Prevention : A Publication of the American Association for Cancer Research, Cosponsored by the American Society of Preventive Oncology*, 20(10), 2127–2131. https://doi.org/10.1158/1055-9965.EPI-11-0437

Chapman, K. A., Machado, S. S., van der Merwe, K., Bryson, A., & Smith, D. (2022). Exploring primary care non-attendance: A study of low-income patients. *Journal of Primary Care & Community Health*, 13, 1-11. https://doi.org/10.1177/21501319221082352

Dayaratna, K. D. (2012, November 7). Studies show: Medicaid patients have worse access and outcomes than the privately insured. *The Heritage Foundation*. 2740-2745. Retrieved March 1, 2023, from https://www.heritage.org/health-care-reform/report/studies-show-medicaid-patients-have-worse-access-and-outcomes-the

Dickman, S. L., Himmelstein, D. U., & Woolhandler, S. (2017). Inequality and the health-care system in the USA. *The Lancet*, 389(10077), 1431–1441. https://doi.org/10.1016/S0140-6736(17)30398-7

Ford, A., Togni, G. de, & Miller, L. (2021). Hormonal health: Period tracking apps, wellness, and self-management in the era of surveillance capitalism. *Engaging Science, Technology, and Society*, 7(1), 48–66. https://doi.org/10.17351/ests2021.655

Heywang-Köbrunner, S. H., Hacker, A., & Sedlacek, S. (2011). Advantages and Disadvantages of Mammography Screening. *Breast Care*, 6(3), 199–207. https://doi.org/10.1159/000329005

Imbarlina,E. (2023). ANT model for lower SES women diagnosed with BrCa. [Figure 4]. *STS Research Outline* (Unpublished undergraduate thesis). School of Engineering and Applied Science, University of Virginia. Charlottesville, VA.

Imbarlina, E. (2023). Envisioned linear ANT model for lower SES women diagnosed with BrCa. [Figure 5]. *STS Research Outline* (Unpublished undergraduate thesis). School of Engineering and Applied Science, University of Virginia. Charlottesville, VA.

Kalager, M., & Bretthauer, M. (2020). Improving cancer screening programs. *Science, 367*(6474), 143–144. https://doi.org/10.1126/science.aay3156Ko, N. Y., Hong, S., Winn, R. A., & Calip, G. S. (2020). Association of insurance status and racial disparities with the detection of early-stage breast cancer. *JAMA Oncology*, 6(3), 385–392. https://doi.org/10.1001/jamaoncol.2019.5672

Law, J., & Callon, M. (1988). Engineering and sociology in a military aircraft project: A network analysis of technological change. *Social Problems*, 35(3), 284–297. https://doi.org/10.2307/800623

Loh, H.-Y., Norman, B. P., Lai, K.-S., Rahman, N. M. A. N. Abd., Alitheen, N. B. M., & Osman, M. A. (2019). The Regulatory Role of MicroRNAs in Breast Cancer. *International Journal of Molecular Sciences*, 20(19), 4940–4967. https://doi.org/10.3390/ijms20194940

Marrugo-Ramírez, J., Mir, M., & Samitier, J. (2018). Blood-based cancer biomarkers in liquid biopsy: A promising non-invasive alternative to tissue biopsy. *International Journal of Molecular Sciences*, 19(10), 2877-2898. https://doi.org/10.3390/ijms19102877

Quaife, S. L., Winstanley, K., Robb, K. A., Simon, A. E., Ramirez, A. J., Forbes, L. J. L., Brain, K. E., Gavin, A., & Wardle, J. (2015). Socioeconomic inequalities in attitudes towards cancer: An international cancer benchmarking partnership study. *European Journal of Cancer Prevention*, 24(3), 253–260. https://doi.org/10.1097/CEJ.0000000000000140

Scully, O. J., Bay, B.-H., Yip, G., & Yu, Y. (2012). Breast cancer metastasis. *Cancer Genomics & Proteomics*, 9(5), 311–320.

Sprague, B. L., Trentham-Dietz, A., Gangnon, R. E., Ramchandani, R., Hampton, J. M., Robert, S. A., Remington, P. L., & Newcomb, P. A. (2011). Socioeconomic status and survival after an invasive breast cancer diagnosis. *Cancer,* 117(7), 1542–1551. https://doi.org/10.1002/cncr.25589

Stage at Diagnosis | Cancer Trends Progress Report. (2022). National Cancer Institute. https://progressreport.cancer.gov/diagnosis/stage

Study: Without Medicaid expansion, poor forgo medical care. (n.d.). AP News. Retrieved November 21, 2022, from https://apnews.com/article/health-north-america-ap-top-news-elections-medicaid-8fbf0ba4b11a4c45b1344bdbbe3c94d9

Toyoda, Y., Oh, E. J., Premaratne, I. D., Chiuzan, C., & Rohde, C. H. (2020). Affordable Care Act state-specific Medicaid expansion: Impact on health insurance coverage and breast cancer screening rate. *Journal of the American College of Surgeons*, 230(5), 775–783. https://doi.org/10.1016/j.jamcollsurg.2020.01.031

VanDyke, S. D., & Shell, M. D. (2017). Health beliefs and breast cancer screening in rural Appalachia: An evaluation of the health belief model. *The Journal of Rural Health*, *33*(4), 350–360. https://doi.org/10.1111/jrh.12204