

Trends in Utilization and Costs of *BRCA* Testing among Women Ages 18-64 Years in the United States, 2003-2014

Running title: *BRCA* testing trends in the United States

Zhuo Chen, PhD^{1,2,3*}, Katherine Kolor, PhD^{1,*†}, Scott D. Grosse, PhD⁴, Juan L. Rodriguez, MPH, MS⁵, Julie A. Lynch, PhD^{6,7}, Ridgely Fisk Green, PhD^{1,8}, W. David Dotson, PhD¹, M. Scott Bowen, MPH¹, and Muin J. Khoury, MD, PhD¹

¹Office of Public Health Genomics; Center for Surveillance, Epidemiology and Laboratory Services; Centers for Disease Control and Prevention (CDC)

²University of Georgia

³University of Nottingham Ningbo China

⁴National Center on Birth Defects and Developmental Disabilities, CDC

⁵Division of Cancer Prevention and Control, National Center for Chronic Disease Prevention and Health Promotion, CDC

⁶U.S. Department of Veterans Affairs Salt Lake City Healthcare System

⁷RTI International, Waltham, MA

⁸Carter Consulting, Inc.

*These authors contributed equally to this work.

†Corresponding author: 1600 Clifton Rd NE, MS-E33, Atlanta, GA 30333; kkolor@cdc.gov; (p) 404.498.0079; (f) 404.498.0140

Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of Centers for Disease Control and Prevention or the Veterans Health Administration.

ABSTRACT

Purpose: We examined twelve-year trends in *BRCA* testing rates and costs in the context of clinical guidelines, national policies, and other factors.

Methods: We estimated trends in *BRCA* testing rates and costs from 2003 to 2014 for women ages 18-64 years using private claims data and publicly reported revenues from the primary *BRCA* testing provider.

Results: The percentage of women with zero out-of-pocket payments for *BRCA* testing increased during 2013-2014, after seven years of general decline, coinciding with a clarification of Affordable Care Act coverage of *BRCA* genetic testing. Beginning in 2007, family history accounted for an increasing proportion of women with *BRCA* tests compared with personal history, coinciding with *BRCA* testing guidelines for primary care settings and direct-to-consumer advertising campaigns. During 2013-2014, *BRCA* testing rates based on claims grew at a faster rate than revenues, following three years of similar growth, consistent with increased marketplace competition. In 2013, *BRCA* testing rates based on claims increased 57%, compared with 11% average annual increases over the preceding three years, coinciding with celebrity publicity.

Conclusions: The observed trends in *BRCA* testing rates and costs are consistent with possible effects of several factors, including the Affordable Care Act, clinical guidelines and celebrity publicity.

INTRODUCTION

Genetic testing for mutations in the *breast cancer 1 (BRCA1)* and *breast cancer 2 (BRCA2)* genes to identify women at increased risk for breast and ovarian cancer who could benefit from preventive interventions has been supported by evidence-based guidelines for over a decade.¹ Moreover, for women affected by these cancers, knowing whether they have a *BRCA* mutation can affect their treatment decisions, including surgical and drug treatments.^{2,3} Current guidelines from the U.S. Preventive Services Task Force (USPSTF), the National Comprehensive Cancer Network (NCCN) and others, outline personal and/or family history screening criteria that can be used in the primary care or specialty setting to identify patients at increased risk for pathogenic *BRCA* mutations.^{1,2,4-10}

Women with pathogenic *BRCA* mutations have an estimated 45-65% risk of breast cancer and a 17-39% risk of ovarian cancer by age 70, as compared with a 7% risk of breast cancer and 0.6% risk of ovarian cancer by age 70 in the general population.^{1,11} Timely ascertainment of these women allows for preventive interventions, including enhanced screening, chemoprevention, or prophylactic surgery to remove the breasts and/or ovaries, that can significantly decrease morbidity and mortality. Prophylactic mastectomy can reduce the risk of breast cancer by 85-100%, and prophylactic oophorectomy can reduce the risk of ovarian cancer by 69-100% and breast cancer by 37-100%.¹

BRCA test utilization and costs in the United States may be influenced by numerous factors, such as increased education, awareness, professional society recommendations, clinical guidelines, scientific evidence, evolving technology and national policies.^{12,13,14} A recent example is the Patient Protection and Affordable Care Act (ACA), which requires most private health plans to provide in-network coverage without cost-sharing (such as copayments, deductibles, or co-insurance) for *BRCA* genetic counseling as a preventive service for women whose family history is associated with an increased risk for deleterious *BRCA* mutations in accordance with the USPSTF recommendation.^{15,16,17} A potential outcome of ACA coverage of *BRCA* testing would be an increase in the number of people who pay nothing out of pocket for testing post-ACA implementation compared with pre-

implementation. Another example is the U.S. Supreme Court decision in June 2013 that invalidated specific *BRCA* test patents, with a number of other clinical laboratories subsequently offering *BRCA* testing in the U.S.¹⁸

Understanding how these many factors may, individually and collectively, directly or indirectly, influence *BRCA* testing rates and costs is complex, and subject to the limitations of available data for assessing use of *BRCA* testing in the general U.S. population. *BRCA* genetic testing is not captured currently in any national surveillance system. Medical claims data have been used in a number of studies on general *BRCA* testing trends among the nation's insured, including guideline-concordant use. For example, a recent study examined trends in *BRCA* testing in the United States from 2004 to 2014 based on claims data from a single private health insurance provider and found that use of *BRCA* testing has shifted from primarily patients affected by cancer to unaffected patients.¹⁹ Other studies have found that clinical use of *BRCA* testing did not follow current guidelines and remained underutilized.²⁰⁻²²

Two recent studies examined the impact of a May 2013 celebrity Op-Ed¹² using health claims data and demonstrated an increase in *BRCA* testing coinciding with the publicity. However, the increase in *BRCA* test use was associated with lower utilization of follow-up health services, such as mastectomy, mammography, and MRI rates among women who had *BRCA* tests.^{14,23} These types of studies are feasible because *BRCA* testing can be identified in medical claims using either *BRCA*-specific Healthcare Common Procedure Coding System (HCPCS) billing codes that were introduced beginning in 2001 or gene-specific Current Procedural Terminology (CPT) billing codes for *BRCA* testing introduced during 2012-2013. However, the HCPCS codes used prior to 2013 likely incompletely ascertain *BRCA* testing, because a portion of *BRCA* tests were billed using non-specific molecular diagnostic codes.²⁴ Alternative methods and data sources are needed to reliably and comprehensively capture those tests.

We examined trends in utilization, median total payment (to a provider), and expected patient out-of-pocket (OOP) payments for *BRCA* testing from 2003 to 2014 in a large commercially insured population. We compared our findings with estimated rates of *BRCA* testing based on reported revenue from Myriad Genetics,

Incorporated (Salt Lake City, UT), the presumed sole provider of *BRCA* testing through June 2013. We describe *BRCA* testing trends over this time period by patient age, geographic region, and codes for personal or family history of breast or ovarian cancer.

MATERIALS AND METHODS

Twelve years of claims data from 2003 through 2014 for women ages 18-64 years were extracted from Truven Health Analytics MarketScan Commercial Claims and Encounters (CCAЕ) databases licensed to the Centers for Disease Control and Prevention.²⁵ The number of women enrollees ages 18-64 years included in the analyses ranged from as low as 6.2 million in 2006 to as high as 20.6 million in 2012, including capitated and non-capitated plans and partial year enrollment. The MarketScan CCAЕ databases contain enrollment data for adults and dependent children with employer-sponsored health insurance and linked utilization and payment data for inpatient, outpatient, and laboratory services for those same individuals. MarketScan claim and patient-level information, including age, sex, geographic location, diagnostic codes, procedure codes, and total allowable charges (health plan payments, expected OOP payment), were analyzed. We adjusted the payment variables to 2014 dollars using the Personal Consumption Expenditures index.²⁶

BRCA tests were ascertained from both outpatient and inpatient claims. Claims of *BRCA* testing were extracted using Healthcare Common Procedure Coding System (HCPCS) codes (S3818-S3823) and Current Procedural Terminology (CPT) codes (81211-81217) (Supplementary Table S1). To increase the specificity of our study, we excluded *BRCA* testing ordered under non-specific molecular diagnostic CPT codes from our analysis. Medical claims data will not ascertain *BRCA* testing done as self pay. We defined four sub-types of *BRCA* tests based on billing codes: full-gene sequencing, known familial variant, Ashkenazi panel, and large rearrangement tests (Supplementary Table S1).

The annual calendar year utilization rates of any *BRCA* test and subtypes were calculated as the number of women enrollees ages 18-64 years who had at least one claim in that calendar year that contains one of the *BRCA* testing procedure codes divided by the total number of women ages 18-64 years enrolled at any point

during that year. For each study year, enrollee age was defined as the age on January 1 or at the start of enrollment period for partial year enrollees. Rates were also calculated by age group (ages 18-34, 35-44, 45-54, and 55-64 years), and by United States census region (Northeast, Midwest, South, and West).

We used median total payment to approximate the average payment for *BRCA* tests as it is less influenced by outliers and negative values which were used to adjust erroneous coding, as in credits to offset duplicate payments. Total payment is the total gross payment to providers for a specific service. It is the amount eligible for payment after applying pricing guidelines such as fee schedules and discounts but before applying deductibles, copayments, and coordination of benefits.²⁷ Claims with zero payments account for a small percentage of the sample and were removed from median payment and OOP payments calculations because these can reflect records added by Truven Health Analytics to adjust for non-financial coding errors, some claims from capitated plans, bundled payments for episodes of care in non-capitated plans, or enrollees with another payment source that was not recorded. Patient out-of-pocket payments were calculated as the sum of copayment, coinsurance, and deductible payments for each claim.

We grouped cases into four diagnosis groups: 1) newly diagnosed breast or ovarian cancer (incident), 2) previously diagnosed breast or ovarian cancer (non-incident), 3) family history of breast cancer or ovarian cancer, and 4) others. Previous diagnosis of breast cancer was based on either a personal history of breast cancer recorded within one month after a procedure code for treatment of breast cancer or a breast cancer claim during 2002; previous diagnosis of ovarian cancer was based on a claim for ovarian cancer in 2002 (Supplementary Table S2). We acknowledge that family history and personal history may not be reliably recorded or categorized. Within each subcategory, we examined the percentage of the enrollees who had zero OOP.

BRCA testing revenues aggregated over calendar year were obtained from quarterly and annual reports filed with the U.S. Securities and Exchange Commission by Myriad Genetics, Inc., the presumed exclusive provider of *BRCA* sequencing tests until June 2013.^{18,28} Additional *BRCA* testing providers entered the market beginning in

June 2013; however, we did not capture those revenues in our estimates. *BRCA* testing rates based on revenue were calculated for each year during the study period using the MarketScan median payment for any *BRCA* test and U.S. Census estimates for women 18-64 years. We adjusted revenues to 90% to account for *BRCA* testing in the 65 and over group, which we roughly estimate at about 10% based on the current study and 2013 Medicare data.²⁹ Additional assumptions are described in the Supplemental methods and Supplementary Table S3.

RESULTS

Trends in BRCA testing utilization 2003-2014

BRCA testing rates, whether estimated from claims or revenues, exhibited higher overall growth rates 2003-2009 compared to 2010-2014. From 2003 to 2009, the growth in *BRCA* testing rates using HCPCS codes in claims data was 6 times as rapid as the growth in the revenue data (Figure 1A; Supplementary Table S3). During 2009 to 2012 the growth in testing rates was similar between the two sources. From 2012 to 2014, the percentage of women with employer-sponsored insurance (ESI) who underwent *BRCA* testing increased by 68%, whereas revenue estimates increased 12%.

Rates of utilization of any *BRCA* test in MarketScan CCAE databases increased from 2.68 per 100,000 in 2003 to 240.99 per 100,000 in 2014 in women ages 18-64 years (Figure 1B; Supplementary Tables S4). In 2013, *BRCA* testing rates based on claims data increased by 57%, relative to 2012 levels, compared to annual increases of 9%, 10% and 13% over the preceding three years, and 7% the following year. Most (70%) of the observed increase in *BRCA* testing rates in 2013 occurred during April through June (Supplemental Figure S1). Annualized *BRCA* testing rates per 100,000 for selected months in 2013 are: 202.9 (March), 236.2 (April), 293.7 (May), 306.8 (June), and 296.4 (July).

More than 193,000 women who had *BRCA* testing were identified from medical claims. Among women who had any *BRCA* test, 90% had full-gene sequencing tests, with percentages increasing over the study period from 86% in 2003 to 93% in 2014. Known variants and Ashkenazi panel testing each accounted for 5% of women who had

BRCA tests, with the percentages for each decreasing from 7% in 2003 to 4% in 2014 (Supplementary Table S4). Large rearrangement tests showed a rapid increase from 46.69 per 100,000 in 2012 to 208.24 per 100,000 in 2014, performed in 86% of women who had *BRCA* tests in 2014. The average number of *BRCA* testing claims among women remained stable at about 1.1 during 2004-2011, consistent with each woman having about one *BRCA* test on average. The average number of *BRCA* testing claims increased to 1.5 in 2012, and then to 1.9 in 2013 and 2014, consistent with more women having two claims for *BRCA* test subtypes with the implementation of a specific billing code for large rearrangement tests.

BRCA testing trends by age group

The highest rates of *BRCA* testing occurred among women ages 45-54 years, and the lowest rates were among women ages 18-34 years (Figure 2A; Supplementary Table S5). The proportions of *BRCA* testing occurring in the youngest (18-34 years) and oldest (55-64 years) age groups increased over the study period (Figure 2B; Supplementary Table S5).

Diagnosis codes associated with BRCA testing

From 2003-2012 more *BRCA* testing was performed in women with diagnosis codes indicative of a personal history of breast or ovarian cancer (newly and previously diagnosed) compared with a family history of these cancers (Figure 3; Supplementary Table S6). Starting in 2013, *BRCA* testing with diagnosis codes indicative of a family history of cancer exceeded testing associated with personal history of breast cancer or ovarian cancer (47.9% versus 40.7%).

Trends in BRCA testing payments and OOP costs, 2003-2014

Median claim-level payment remained relatively stable over the study period for all *BRCA* test subtypes; however, median patient-level payment for any *BRCA* test increased in 2013 from \$3,130 to \$3,585, consistent with increased patient-level costs following the implementation of a specific billing code for large rearrangement tests (Figure 4A; Supplementary Table S7). Among women who had any *BRCA* test, the

proportion of women with zero OOP payments decreased from 78% in 2005 to 63% in 2012, then increased to 71% and 80% in 2013 and 2014, respectively (Figure 4A; Supplementary Table S7). Women with diagnosis codes indicating a family history of breast or ovarian cancer exhibited a greater relative increase in zero OOP expenses 2012-2013 compared with those with previously diagnosed personal history of breast or ovarian cancer (45% vs. 27%) (Figure 4B; Supplementary Table S8).

Geographic distribution of BRCA testing

BRCA testing rates were highest in the Northeast region throughout the study period (Figure 5A/B; Supplementary Table S9). Although the regional gaps in relative testing rates generally decreased over the study period (Figure 5B), the Northeast region exhibited the greatest increase in 2013 relative to 2012 (78.6%). In 2014, *BRCA* testing rates dropped in the Northeast, but continued to increase in the other regions.

DISCUSSION

The difference in growth rates in apparent *BRCA* testing rates observed between the revenue and MarketScan data sources from 2003 to 2009 most likely reflects increasing use of HCPCS codes and decreasing use of non-specific molecular diagnostic CPT codes as a proportion of all *BRCA* testing billing codes. That is, although the claims data underperform the revenue data in capturing *BRCA* testing during this period, there was increasing convergence over time. The similar rates of growth in *BRCA* testing from 2010 through 2012 from the two data sources suggests similar level of accuracy in ascertainment during those years.

Beginning in 2013, claims data are expected to capture a higher proportion of *BRCA* tests due to the introduction of specific CPT codes for *BRCA* testing and the elimination of certain nonspecific billing codes. Additionally, claims data are expected to outperform revenue data in ascertaining *BRCA* testing starting in mid-2013 given the U.S. Supreme Court decision in June 2013 that cleared the way for other laboratories to enter the market. Indeed, *BRCA* testing rates based on medical claims grew at a substantially faster rate than revenues during 2013-2014.

The rate of any *BRCA* testing among women increased by 57% in 2013, compared with average annual increases of 11% in the three preceding years. The timing of the increase in *BRCA* testing during April-June 2013 coincided with publication of a New York Times Op-ed on May 14, 2013, and was geographically concentrated in the Northeast region.¹² These findings are consistent with a recently published analysis of MarketScan CCAE data which showed that the increase in *BRCA* testing during 2013 occurred within a 15-day period following the publication of the Op-ed, and the increase was sustained throughout 2013.¹⁴ In addition, the Centers for Medicare & Medicaid Services issued a policy implementing specific molecular diagnostic CPT codes and eliminating non-specific billing codes, effective in January 1, 2013, and implemented April 1, 2013.³⁰ Our results show a 16% increase in *BRCA* testing occurring during the month of April 2013, prior to publication of the Op-ed, which could reflect in part the implementation of this policy.

The 2013 increase in *BRCA* testing also followed a February 2013 ACA clarification that *BRCA* testing, as well as counseling, was a covered preventive service for women whose family history is associated with an increased risk for deleterious mutations in the *BRCA1* or *BRCA2* genes.^{31,32} Notably, we observed a reversal of a trend toward decreasing proportions of women with zero OOP costs, with a 28% relative increase from 2012 to 2014 for all women who had *BRCA* tests, and a 46% increase for *BRCA* testing based on family history. The remaining 14% with positive OOP among those tested based on family history may be due to various reasons including that “grandfathered” plans were exempt from the preventive services provision of the ACA—in 2015, about 25% of workers covered in ESI were enrolled in grandfathered plans³³—or, because the family history did not meet USPSTF criteria as required by the ACA.

The steady increase in the proportion of *BRCA* testing associated with a diagnosis code of family history of breast or ovarian cancer observed starting in 2007 is consistent with the findings of Guo et al.¹⁹ This shift occurred in the context of the 2005 USPSTF *BRCA* recommendation, which promoted referral for *BRCA* counseling of unaffected women based on family history risk assessment. The USPSTF recommendation is notable as the first *BRCA* recommendation intended for primary care providers, whereas the earlier *BRCA*

recommendations were targeted toward specialists in medical genetics and oncology. The shift also occurred in the context of regional direct-to-consumer advertising campaigns for *BRCA* testing services during 2007-2011.^{28,34,35}

The median yearly payment per enrollee tested was fairly level at about \$3,100 until 2013 when it increased to \$3,535. That increase likely reflects the introduction of a specific CPT code for large rearrangement test billing in 2012 and the incorporation of large rearrangement testing into clinical guidelines. Indeed, the average number of claims for each enrollee, which had been stable at about 1.1 during 2004-2012, increased to 1.5 in 2012, and then to 1.9 in 2013 and 2014. That increase is consistent with the use of large rearrangement tests as a reflex test when *BRCA* sequencing tests are negative.

This study has several strengths. The MarketScan CCAE databases include a large number of clinical encounter records, with 18.6 million women enrollees ages 18-64 in 2014, which accounts for about 18% of U.S. women ages 18-64. The MarketScan CCAE databases have the actual amounts paid by health plans and the residual amounts expected from patients instead of charges, which do not reflect the true cost of *BRCA* tests. We compared the overall observed trends in *BRCA* testing rates over the study period with revenue data. We limited our MarketScan analysis to specific *BRCA* billing codes.

The study has several limitations. MarketScan CCAE databases contains include women who have ESI, but not those who are not insured, have public insurance, or purchase insurance themselves. The sample is not nationally representative of the population with ESI or the general U.S. population. The number of plans and enrollees in the MarketScan CCAE databases available to the researchers varied over the study period, generally increasing until 2013, when a drop in the number of enrollees was observed, including a 17% decrease in women enrollees ages 18-64 years relative to 2012. The MarketScan analysis does not capture *BRCA* tests ordered under non-specific molecular diagnostic CPT codes or those self paid; however, the revenue analysis should capture these tests until June 2013. The analyses do not examine whether the *BRCA* testing that

occurred was in accordance with clinical guidelines. The reliability of the coding of *BRCA* tests may have evolved over time, which could have impacted the completeness of ascertainment of *BRCA* tests, particularly prior to 2013.^{22,24} We are limited by the nature of the claims data which involves recording errors, adjudication, and other factors. Neither the MarketScan nor the Myriad revenue analyses would detect if other laboratories aside from Myriad offered *BRCA* testing using non-specific molecular diagnostic CPT codes.

Observed trends in *BRCA* testing rates and zero OOP payments in 2003-2014 are consistent with a number of factors expected to influence the uptake of *BRCA* testing, including clarification of full coverage of *BRCA* testing for many people under the ACA, the U.S. Supreme Court decision invalidating certain *BRCA* gene patents, clinical guidelines, advertising, and celebrity publicity. This study is unique in its ability to track trends in rates of genetic testing for *BRCA* in the United States for specific demographic groups prior to 2012-2013. However, this analysis was not able to track the extent to which the increased uptake of *BRCA* testing was targeted to women at elevated risk or that it resulted in increased uptake of preventive services among women who found that they had a *BRCA* mutation. A comprehensive analysis of the likely population health impact of increased uptake of *BRCA* testing is needed but may require additional sources of data. Assessment of trends in rates of genetic testing for other genes or conditions, such as Lynch syndrome, also remains challenging.

Supplementary information is available at the *Genetics in Medicine* website.

REFERENCES:

1. Moyer VA. Risk assessment, genetic counseling, and genetic testing for BRCA-related cancer in women: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med.* 2014;160(4):271-281.
2. National Comprehensive Cancer Network. Clinical Practice Guidelines in Oncology. Genetic/Familial High Risk Assessment: Breast and Ovarian. . 2016. http://www.nccn.org/professionals/physician_gls/pdf/genetics_screening.pdf. Accessed August 29, 2016.
3. U.S. Food and Drug Administration. FDA approves Lynparza to treat advanced ovarian cancer. 2014. <http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm427554.htm>. Accessed July 25, 2016.
4. Robson ME, Bradbury AR, Arun B, et al. American Society of Clinical Oncology Policy Statement Update: Genetic and Genomic Testing for Cancer Susceptibility. *J Clin Oncol.* 2015;33(31):3660-3667.
5. Berliner JL, Fay AM, Cummings SA, Burnett B, Tillmanns T. NSGC practice guideline: risk assessment and genetic counseling for hereditary breast and ovarian cancer. *J Genet Couns.* 2013;22(2):155-163.
6. Balmana J, Diez O, Rubio I, Castiglione M, Group EGW. BRCA in breast cancer: ESMO Clinical Practice Guidelines. *Ann Oncol.* 2010;21 Suppl 5:v20-22.
7. American College of Obstetricians Gynecologists. ACOG Practice Bulletin No. 103: Hereditary breast and ovarian cancer syndrome. *Obstet Gynecol.* 2009;113(4):957-966.
8. Lancaster JM, Powell CB, Kauff ND, et al. Society of Gynecologic Oncologists Education Committee statement on risk assessment for inherited gynecologic cancer predispositions. *Gynecol Oncol.* 2007;107(2):159-162.
9. Hampel H, Bennett RL, Buchanan A, et al. A practice guideline from the American College of Medical Genetics and Genomics and the National Society of Genetic Counselors: referral indications for cancer predisposition assessment. *Genet Med.* 2015;17(1):70-87.
10. American Society of Breast Surgeons. Position Statement on BRCA Genetic Testing for Patients With and Without Breast Cancer. 2012. https://www.breastsurgeons.org/new_layout/about/statements/PDF_Statements/BRCA_Testing.pdf. Accessed July 25, 2016.
11. Howlader N, Noone AM, Krapcho M, et al. SEER Cancer Statistics Review, 1975–2012,. April 2015. http://seer.cancer.gov/csr/1975_2012/browse_csr.php?sectionSEL=4&pageSEL=sect_04_table.17.html.
12. Jolie A. My Medical Choice. [Op-Ed]. May 14, 2014; http://www.nytimes.com/2013/05/14/opinion/my-medical-choice.html?_r=0.
13. Evans DG, Barwell J, Eccles DM, et al. The Angelina Jolie effect: how high celebrity profile can have a major impact on provision of cancer related services. *Breast Cancer Res.* 2014;16(5):442.
14. Desai S, Jena AB. Do celebrity endorsements matter? Observational study of BRCA gene testing and mastectomy rates after Angelina Jolie's New York Times editorial. *BMJ.* 2016;355:i6357.
15. Patient Protection and Affordable Care Act, 42 U.S.C. § 18001. 2010.
16. U.S. Department of Health and Human Services. Preventive Services Covered Under the Affordable Care Act. <http://www.hhs.gov/healthcare/facts/factsheets/2010/07/preventive-services-list.html>. Accessed July 22, 2016.
17. Centers for Medicare and Medicaid Services. Affordable Care Act Implementation FAQs – Set 12. 2013; https://www.cms.gov/CCIIO/Resources/Fact-Sheets-and-FAQs/aca_implementation_faqs12.html. Accessed July 22, 2016.
18. Cook-Deegan R, Niehaus A. After Myriad: Genetic Testing in the Wake of Recent Supreme Court Decisions about Gene Patents. *Curr Genet Med Rep.* 2014;2(4):223-241.
19. Guo F, Hirth JM, Lin YL, et al. Use of BRCA Mutation Test in the U.S., 2004-2014. *Am J Prev Med.* 2017.
20. Levy DE, Byfield SD, Comstock CB, et al. Underutilization of BRCA1/2 testing to guide breast cancer treatment: black and Hispanic women particularly at risk. *Genet Med.* 2011;13(4):349-355.

21. Armstrong J, Toscano M, Kotchko N, et al. Utilization and Outcomes of BRCA Genetic Testing and Counseling in a National Commercially Insured Population: The ABOUT Study. *JAMA Oncol.* 2015;1(9):1251-1260.
22. Wright JD, Chen L, Tergas AI, et al. Underuse of BRCA testing in patients with breast and ovarian cancer. *Am J Obstet Gynecol.* 2016;214(6):761-763.
23. Roberts MC, Dusetzina SB. The effect of a celebrity health disclosure on demand for health care: trends in BRCA testing and subsequent health services use. *J Community Genet.* 2017;8(2):141-146.
24. Lynch J, Berse B. Methods to identify BRCA testing in claims data. *Am J Obstet Gynecol.* 2016;215(1):133-134.
25. Truven Health Analytics. Truven Health MarketScan® Research Databases, Commercial Claims and Encounters Medicare Supplemental, Data Year 2003-2014 Edition.
26. Agency for Healthcare Research and Quality. Medical Expenditure Panel Survey: Using appropriate price indices for analysis of health care expenditures or income across multiple years. http://meps.ahrq.gov/mepsweb/about_meps/Price_Index.shtml Accessed July 22, 2016.
27. Truven Health Analytics. Truven Health MarketScan® Research Databases, Commercial Claims and Encounters Medicare Supplemental, Data Year 2012 Edition.12.
28. U.S. Securities and Exchange Commission. EDGAR Search Results: Myriad Genetics. 2016; <https://www.sec.gov/cgi-bin/browse-edgar?action=getcompany&CIK=0000899923&owner=exclude&count=40&hidefilings=0>. Accessed September 8, 2016.
29. Lynch JA, Berse B, Dotson WD, Khoury MJ, Coomer N, Kautter J. Utilization of genetic tests: analysis of gene-specific billing in Medicare claims data. *Genet Med.* 2017.
30. Centers for Medicare and Medicaid Services. Healthcare Common Procedure Coding System (HCPCS) Codes Subject to and Excluded from Clinical Laboratory Improvement Amendments (CLIA) Edits. 2013; <https://www.cms.gov/Outreach-and-Education/Medicare-Learning-Network-MLN/MLNMattersArticles/Downloads/mm8162.pdf>. Accessed April 20, 2017.
31. Centers for Medicare and Medicaid Services. Affordable Care Act Implementation FAQs – Set 12. 2013; https://www.cms.gov/CCIIO/Resources/Fact-Sheets-and-FAQs/aca_implementation_faqs12.html. Accessed July 22, 2016.
32. Department of Labor. FAQs About Affordable Care Act Implementation (Part XII). 2013; <https://www.dol.gov/sites/default/files/ebsa/about-ebsa/our-activities/resource-center/faqs/aca-part-xii.pdf>. Accessed January 13, 2017.
33. Kaiser Family Foundation Health Research and Educational Trust. 2015 Employer Health Benefits Survey. 2015. <http://kff.org/health-costs/report/2015-employer-health-benefits-survey/>. Accessed July 22, 2016.
34. Centers for Disease C, Prevention. Genetic testing for breast and ovarian cancer susceptibility: evaluating direct-to-consumer marketing--Atlanta, Denver, Raleigh-Durham, and Seattle, 2003. *MMWR Morb Mortal Wkly Rep.* 2004;53(27):603-606.
35. Direct-to-Consumer Genetic Testing: Business Prospects in the United States. *Insight Pharma Reports.* http://www.insightpharmareports.com/uploadedFiles/Reports/Reports/Genetic_Testing/Consumer_Geonomics_sample_pages.pdf. Accessed August 30, 2016.

FIGURE LEGENDS

Figure 1. Rates of *BRCA* tests and subtypes per 100,000 women ages 18-64 years: MarketScan and revenue estimates. A. Utilization rates of any *BRCA* test and subtypes among women ages 18-64 years, 2003-2014 (per 100,000 MarketScan CCAE databases enrollees). Subtypes include full-gene sequencing, known variant, Ashkenazi panel and large rearrangement tests. B. Growth in *BRCA* testing rates among women ages 18-64 years per 100,000, MarketScan CCAE databases vs. revenue estimates, 2003-2014.

Figure 2. Rates of *BRCA* testing by age group per 100,000 women ages 18-64 years, MarketScan CCAE databases, 2003-2014 A. *BRCA* test rates (per 100,000 enrollees) among women by age group: 18-34 years, 35-44 years, 45-54 years, 55-64 years. B. Percent of *BRCA* testing among women by age group, 2003-2014.

Figure 3. Percent of *BRCA* testing among women ages 18-64 years by personal or family history of breast or ovarian cancer, MarketScan CCAE databases, 2003-2014. Women with any *BRCA* test stratified by diagnosis groups: family history of breast or ovarian cancer, newly diagnosed personal history of breast or ovarian cancer (incident), previously diagnosed personal history of breast or ovarian cancer (non-incident), and other.

Figure 4. Costs of *BRCA* test and subtypes, MarketScan CCAE databases, 2003-2014. A. Health plan payment amount per enrollee for *BRCA* test and subtypes, and percentage of enrollees with zero out-of-pocket payment for any *BRCA* test (right axis). Subtypes include full-gene sequencing, known variant, Ashkenazi panel and large

rearrangement tests. B. Percentage of zero OOP payment among women by diagnosis group: family history of breast or ovarian cancer, newly diagnosed personal history of breast or ovarian cancer (incident), previously diagnosed personal history of breast or ovarian cancer (non-incident), other.

Figure 5. Regional BRCA Test Rates and Relative Rates per 100,000 women ages 18-64 years, MarketScan CCAE databases 2003-2014. A. BRCA tests rates by geographic region: Northeast, Midwest, South, West. B. Relative BRCA Tests Rates by geographic region, compared to Northeast region. Northeast: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York, Pennsylvania. Midwest: Illinois, Indiana, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota. South: Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Mississippi, Tennessee, Arkansas, Louisiana, Oklahoma, Texas. West: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming, Alaska, California, Hawaii, Oregon, Washington.