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Review Article

Reducing overuse of cervical cancer screening: A systematic review

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ABSTRACT

Overuse of clinical preventive services increases healthcare costs and may deprive underserved patients of necessary care. Up to 45% of cervical cancer screening is overuse. We conducted a systematic review of correlates of overuse of cervical cancer screening and interventions to reduce overuse. The search identified 25 studies (20 observational; 5 intervention). Correlates varied by the type of overuse measured (i.e., too frequent, before/after recommended age to start or stop screening, after hysterectomy), the most common correlates of overuse related to patient age (n = 7), OBGYN practice or provider (n = 5), location (n = 4), and marital status (n = 4). Six observational studies reported a decrease in overuse over time. Screening overuse decreased in all intervention studies, which used before-after designs with no control or comparison groups. Observational studies suggest potential targets for de-escalating overuse. Randomized clinical trials are needed to establish best practices for reducing overuse.

1. Background

As new evidence emerges, changes in recommendations for routine medical care are common (Prasad et al., 2013). The successful dissemination and implementation of new recommendations can improve patient care and reduce healthcare costs (Prasad and Ioannidis, 2014). Yet, use of low-value preventive services is prevalent (Elshaug et al., 2012; Schwartz et al., 2014). Low-value services are health care services or procedures that are overused (e.g., screening more often than recommended), misused (e.g., screening with the wrong test), wasted (e.g., screening that is not recommended); or benefit neutral, marginal or harmful to patients (e.g., screening that causes small harms and does not significantly increase chances of survival). According to one study in the United States, 24% of Medicare beneficiaries received at least one low-value service in 2009 (Schwartz et al., 2014). Foregoing use of low-value services, particularly overuse of services, has the potential to improve quality of care while reducing healthcare spending (Colla, 2014).

Overuse of cervical cancer screening results in higher healthcare costs while providing marginal benefits and potential harm to patients (Sawaya et al., 2015). Cervical cancer screening, mainly with Pap (Papanicolaou) testing, is critical for identifying women with cervical precancerous lesions (Wentzensen, 2016) and has contributed to the dramatic decrease in invasive cervical cancer in the United States (Gustafsson et al., 1997). In previous recommendations made in 1996 and 2003, the U.S. Preventive Services Task Force (USPSTF) recommended cervical cancer screening at least every three years (Saslow et al., 2012; U.S. Preventive Services Task Force, 1996; U.S. Preventive Services Task Force, 2003). In 2012, the USPSTF released updated recommendations for cervical cancer screening. Of the five recommendations, four were graded as D (e.g., The USPSTF recommends against the service. There is moderate or high certainty that the service has no net benefit or that the harms outweigh the benefits) and only one received a grade of A (The USPSTF recommends the service. There is high certainty that the net benefit is substantial). The USPSTF recommends screening for cervical cancer in women age 21 to 65 years with cytology (Pap smear) every 3 years or, for women age 30 to 65 years who want to lengthen the screening interval, screening with a

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combination of cytology and human papillomavirus (HPV) testing every 5 years (U.S. Preventive Services Task Force, n.d.). Organizations, including the American College of Obstetricians and Gynecologists and American Cancer Society, harmonized their cervical cancer screening recommendations with the USPSTF recommendations (The American College of Obstertricians and Bynecologists, n.d.; American Cancer Society, n.d.). While periodic screening is useful to detect precancerous cervical lesions, false-positive results from excessive screening can result in unnecessary colposcopies and biopsies among patients who are unlikely to develop invasive cancer, resulting in higher costs, as well as pain and disease-specific distress (Sawaya et al., 2015; Korfage et al., 2012; Welch and Black, 2010).

Adherence to the new cervical cancer screening recommendations is relatively low (Salz et al., 2010; Teoh et al., 2015; Frederiksen et al., 2015). For example, in one cross-sectional study of 135 health care providers in Minnesota, U.S., 88% of health care providers were aware of a change in cervical cancer screening guidelines, but only 61% reported following these guidelines (Teoh et al., 2015). In another study of 216 obstetricians, gynecologists, midwives, nurse practitioners, and physicians practicing in Indiana, U.S., only 38% self-reported following the most current cervical cancer screening guidelines (King et al., 2014). Low adherence to the current guidelines among patients was similarly found in a study of 8000 U.S. women ages 30 years and older in one academic medical center-affiliated group: only 34% of women self-reported receiving guideline-based cervical cancer screening, while 45% were screened more frequently than recommended (Almeida et al., 2013). More research is needed to understand what motivates providers and patients to overuse cervical cancer screening in order to inform interventions that can increase adherence to cervical cancer screening recommendations.

Effective strategies are needed to reduce overuse of preventive services, including the overuse of cervical cancer screening (Prasad and Ioannidis, 2014; Berwick and Hackbarth, 2012). We conducted a systematic review to understand the drivers of cervical cancer screening overuse, and to identify strategies to increase adherence to cervical cancer screening recommendations that have been evaluated. More specifically, our systematic review aimed to answer two research questions: 1) What are correlates of overuse of cervical cancer screening according to observational studies; and 2) What interventions have effectively reduced overuse of cervical cancer screening?

2. Study data and methods

2.1. Search strategy

This analysis reports findings from a larger review on the overuse of cancer screening that included cervical cancer as well as mammography, colon cancer screening, and prostate-specific antigen (PSA) testing for prostate cancer. A biomedical librarian assisted our team with the identification and application of various combinations of search terms related to overuse, cancer screening, and cervical cancer testing to achieve a comprehensive search within each of four databases (i.e., PubMed, CINAHL, Embase, and Cochrane Central Register of Controlled Trials) (see Appendix A1). Because of the unique issues related to cervical cancer screening, this analysis is limited to studies of cervical cancer screening. Fig. 1 contains an outline for the search, screening, and extraction process. After the initial search, the research team reviewed reference lists from eligible articles to identify additional relevant articles for review. The search was conducted between May 27, 2016 and January 13, 2017.

2.2. Inclusion/exclusion criteria

Inclusion criteria for observational and intervention studies were: 1) published between January 1990 and May 2016, 2) original, quantitative research, 3) full-text available in English, 4) included participants

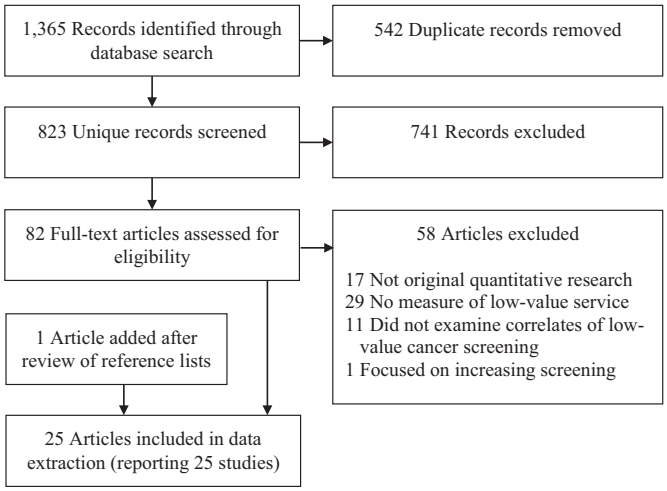

Fig. 1. PRISMA flow diagram.

age ≥18 years, and 5) conducted in a high-income or upper-middle-income country, as defined by the World Bank (World Bank Country and Lending Groups, n.d.). For observational studies, additional inclusion criteria were that the study: 1) examined correlates of overuse of cervical cancer screening, and 2) measured outcomes that included current or past overuse of cervical screening. Additional inclusion criteria for intervention studies were that each study: 1) evaluated an intervention intended to reduce overuse of cervical cancer screening tests, 2) included a measure of change in current or past overuse of cervical cancer screening, and 3) used a pre-post, quasi-experimental or experimental design to assess the impact of the intervention (i.e., collected measurements before and after the intervention, or included a comparison group). We excluded observational and intervention studies that examined: 1) screening generally but not cervical cancer screening specifically, 2) diagnostic testing but not preventive screening, or 3) only post-treatment surveillance.

We defined overuse of cervical cancer screening as screening practices graded as D by the USPSTF. More specifically, the practice was considered overuse if screening for cervical cancer occurred in women younger than age 21 years; in women older than age 65 years who have had adequate prior screening and are not otherwise at high risk for cervical cancer; and in women who have had a hysterectomy with removal of the cervix and who do not have a history of a high-grade precancerous lesion (cervical intraepithelial neoplasia [CIN] grade 2 or 3) or cervical cancer. Studies published before the release of updated screening recommendations were evaluated based on the USPSTF recommendation at the time of the study (2003–2012 or post-2012). Studies published outside of the United States were also evaluated using the USPSTF criteria given the similarity in the included countries' guidelines and the USPSTF guidelines.

2.3. Screening of articles

Article screening and abstraction was completed in three steps: 1) initial screening of titles and abstracts to determine eligibility based on first five inclusion criteria, 2) full screening of titles and abstracts for all inclusion and exclusion criteria, and 3) abstraction of eligible articles. For each step, two reviewers independently screened a random sample of articles and compared results to ensure inter-coder reliability (McHugh, 2012). The study's principal investigator adjudicated disagreements.

2.4. Data extraction

We developed standardized data extraction forms for each research

question, based on previous literature review extraction forms and guidelines, (Zaza et al., 2000; STROBE, 2007), and pilot tested the forms. Reviewers went through training before completing abstractions. Data extraction forms had fields for 1) general article information (i.e., authors, title, journal, funding, purpose, hypotheses), 2) study information (i.e., study design, primary outcomes, location, length, measurement of predictor and outcome variables, eligibility criteria, sample size, response rate, study demographics, statistical analysis, and main findings), and 3) study limitations (descriptions, sampling, measurement, analysis, interpretation of results, and other issues) (Zaza et al., 2000; STROBE, 2007). We identified limitations using guidelines developed by the Task Force on Community Preventive Services for systematic reviews (Zaza et al., 2000). For research question 1 (observational studies), 16 different limitations were possible, while for research question 2 (intervention studies), 21 limitations were possible. Two reviewers independently extracted data from each article, compared their extractions and reconciled differences with a third judge when necessary.

3. Results

3.1. Correlates of overuse

The search identified 20 observational studies (Table 1). Of these, nine were cross-sectional in design, seven were successive independent sample studies, and four were retrospective in design. Sixteen of the 20 studies were conducted in the U.S. Measures of overuse as a primary outcome varied across studies with some studies measuring multiple outcomes: 11 studies investigated cervical cancer screening outside the recommended ages, 10 studies examined too frequent cervical cancer screening, and six studies examined screening in women who had received hysterectomies. Observational studies had a median of 1 limitations (range 0 to 8), with the most common limitations being a low response rate (n = 12) and the sample not being clearly described (n = 7).

Studies examined four overuse outcomes: too frequent (Teoh et al., 2015; Almeida et al., 2013; Arbyn et al., 1997; Barbadoro et al., 2015; Verrilli et al., 2014; Perkins et al., 2013; Arrossi et al., 2010), after a hysterectomy (Almeida et al., 2013; Watson et al., 2000–2010; Marchand et al., 2003; Sirovich and Welch, 2004), before the recommended age to start screening (Henderson et al., 2013; Tsui et al., 2014; Summers et al., 2015), and after the recommended age to stop screening (Teoh et al., 2015; Guo et al., 2015; Royce et al., 2014; Kale et al., 2013; Meissner et al., 2008; Salloum et al., 2014) (Table 2). Studies found five categories of screening overuse correlates: patient demographics (Table 2); patient health characteristics (Almeida et al., 2013; Arbyn et al., 1997; Barbadoro et al., 2015; Perkins et al., 2013; Henderson et al., 2013; Tsui et al., 2014; Guo et al., 2015; Meissner et al., 2008; Salloum et al., 2014); patient healthcare access (Henderson et al., 2013; Tsui et al., 2014; Guo et al., 2015; Royce et al., 2014; Salloum et al., 2014); clinic or provider characteristics (Teoh et al., 2015; Almeida et al., 2013; Perkins et al., 2013; Marchand et al., 2003; Summers et al., 2015; Guo et al., 2015); and other. The most common correlates related to patient age (n = 7), time (overuse decreased over time in longitudinal studies) (n = 6), OBGYN practice or provider (n = 5), geographic location (n = 4), and marital status (n = 4).

Correlates of overuse defined as too frequent were patient age, younger age of first sexual contact, younger age of end of educational attainment, having at least one contraceptive management visit, no reports of having depression or diabetes, lower income, location (varied by study), marital status (widowed or divorced), residing in smaller population density (less than metropolitan city), the practice where the screening took place being private, having two or more pregnancies, male gender of provider, lower provider knowledge, provider specialty (OBGYN), former smoker, no sexually transmitted disease history, high social class, and greater number of clinic visits over study period. The

Table 1
Observational studies, characteristics.

Author (year)	Country	Study design	Limitations[a]	Sample size	Data collection	Type of overuse
Almeida et al. (2013)	U.S.	Retrospective	0	8018 women	2007–2009	Too frequent, after hysterectomy
Arbyn et al. (1997)	Belgium	Cross-sectional	0	1502 women	1995	Too frequent
Arrossi et al. (2010)	Argentina	Cross-sectional	8	19 provinces	2007–008	Too frequent, outside age range
Barbadoro et al. (2015)	Italy	Cross-sectional	1	36,162 women	2004–2005	Too frequent
Guo et al. (2015)	U.S.	Cross-sectional	1	1753 women	2013	Outside age range
Henderson et al. (2013)	U.S.	Successive independent samples study	1	7856 women	2002, 2006–2008	Too frequent
Kale et al. (2013)	U.S.	Successive independent samples study	3	182,063 adults	1999, 2009	Outside age range
Kepka et al. (2014)	U.S.	Cross-sectional	1	9494 women	2010	Outside age range, after hysterectomy
Marchland et al. (2003)	U.S.	Cross-sectional	6	341 providers	1999	Outside age range, after hysterectomy
Meissner et al. (2008)	U.S.	Successive independent samples study	2	43,200 women	1993, 1998, 2000, 2005	Outside age range
Perkins et al. (2013)	U.S.	Cross-sectional	0	397 obstetrician-gynecologists	2011–2012	Too frequent, outside age range, after hysterectomy
Royce et al. (2014)	U.S.	Successive independent samples study	1	27,911 adults	2000–2010	Outside age range
Salloum et al. (2014)	U.S.	Successive independent samples study	1	9760 female Medicare beneficiaries	2001–2007	Outside age range
Sirovich & Welch (2004)	U.S.	Successive independent samples study	2	188,391 women	1992–2000,2002	Outside age range, after hysterectomy
Spence et al. (1996)	U.K.	Retrospective	4	85,594 women	1988–1992	Too frequent
Summers et al. (2015)	U.S.	Retrospective cohort	2	799 women	2009–2010	Outside age range
Teoh (2015)	U.S.	Cross-sectional	1	135 providers	2013–2013	Too frequent, after hysterectomy
Tsui et al. (2014)	U.S.	Retrospective cohort	0	17,337 women	2007–2012	Outside age range
Verrilli et al. (2014)	U.S.	Cross-sectional	4	123 gynecologists	7/2012–8/2012	Too frequent, outside age range
Watson et al. (2014)	U.S.	Successive independent samples study	1	244,721 women	2000, 2010	After hysterectomy

[a] 16 possible limitations; adapted from the Task Force on Community Preventive Services data collection instrument for systematic reviews.

Table 2
Observational studies, correlates.

Author (year)	Variables measured		Outcomes
	Significant[a]	Not significant	
Almeida et al. (2013)	Patient age (higher among 30–50 years vs. older age groups) Contraceptive management visit (at least one) Depression comorbidity (not having depression) Diabetes comorbidity (not having diabetes) Provider type (higher for gynecology than family medicine)	Cerebrovascular disease CME attendance Coronary artery disease Female provider gender Great than 7 years in practice Hypertension Internal medicine specialty Language Number of pap test Race/ethnicity	Too frequent; after cervix is removed
Arbyn et al. (1997)	Age of first sexual contact (odds of overuse increase with age) Age at end of educational studies (overuse increased as age at end of education decreased) Income (higher for < 40,000 compared to higher income) Marital status (higher for widowed compared to other) Sexually transmitted disease (no higher than yes)	Age Employment Family status (e.g. living alone or with others) Number of sexual partners Province Smoking status Use of oral contraceptives	Too frequent
Arrossi et al. (2010)	*No significance testing	*No significance testing	Too frequent; before recommended age; after recommended age
Barbadoro et al. (2015)	Patient age (lower for older 35–64 compared to 24–34) Location (island compared to North-western) Marital status (divorced compared to single) Population density (cities less than metropolitan city) Pregnancy (two or more compared to none) Smoking status (former vs current smoker) Social class (high social class compared to low social class)	Education Perceived health status	Too frequent
Guo et al. (2015)	Patient age (higher 70–74 vs. over 80 years) Clinical visits (have visited OBGYN and have not) Doctor's recommendation for test (yes) Smoking status (former) Visited OBGYN (yes vs no)	Race/ethnicity	After recommended age
Henderson et al. (2013)	Patient age (higher among 18–20 vs. 15–17 years) Born in US (vs outside) Continuous health insurance (yes) Hormonal contraception (yes) Mother's education (some college or more vs less than college) Number of sexual partners in past year (higher for multiple vs one or none) Pregnancy (in last 12 months) Race (black vs white) Residence (higher in non-urban vs urban) Sexual activity (active in last 36 months) Time (decreased over time) Type of health insurance (higher for public health insurance vs private)	HPV[b] vaccination	Before recommended age
Kale et al. (2013)	Time (decreased from 1999 to 2009)		After recommended age
Kepka et al. (2014)	*No significance testing	*No significance testing	After recommended age; after cervix is removed

(*continued on next page*)

Table 2 (*continued*)

Author (year)	Variables measured		Outcomes
	Significant[a]	Not significant	
Marchand et al. (2003)	Provider type (advanced practice nurse vs family physician and OBGYN)		After cervix is removed
Meissner et al. (2008)	Chronic disability (no) Health status (higher for good excellent/good vs fair/poor) Hysterectomy (negatively associated)	Charlson comorbidity index	After recommended age
Perkins et al. (2013)	Location (south) Provider gender (male) Provider specialty (other than OBGYN) Provider type (solo)	Provider age Provider race Provider years in practice Racial composition of practice	Too frequent
Royce et al. (2014)	Patient age (decreased with age) Educational attainment (higher) Health insurance (yes) Location (U.S. south region) Marital status (married) Mortality risk (lower) Time (decreased from 2003 to 2010) Usual source of care (yes)	Race Sex	After recommended age
Salloum et al. (2014)	Patient age (decreased with increasing age) Education (less than high school negatively associated) Health status (fair to poor health negatively associated) Hispanic Household income (< $25,000 negative association) Hysterectomy (negatively associated) Location (metropolitan area); Marital status (married) Race (black) Usual source of care (yes)	History of non-skin cancer Insurance type Residence History of non-skin cancer Insurance type Residence	After recommended age
Sirovich & Welch (2004)		Time	After cervix is removed
Spence et al. (1996)	*No significance testing	*No significance testing	Too frequent
Summers et al. (2015)	Cervical cytology performed (yes) History of cervical intraepithelial neoplasia (yes) Reason for office visit (routine care) Specialty (OBGYN) Time (decreased from 2009 to 2010)	BMI Diagnosis with cytology order History of sexual active Hormonal contraceptive Prior screening Race Type of insurance	Before recommended age
Teoh (2015)	Provider knowledge (lower knowledge)		Too frequent; after recommended age
Tsui et al. (2014)	Patient age (higher among 16–20 vs. 13–15 years) Clinic type (gynecologic) Clinical visits (more) Health insurance (none) HPV[b] vaccination (yes) Language (Spanish) STI[c] test (positive) Time (declined over two periods)	Race	Before recommended age
Verrilli et al. (2014)	Practice type (private)		Too frequent
Watson et al. (2014)	Time (decreased from 2000 to 2010)		After cervix is removed

[a] All correlates were associated with greater overuse with exception of time, where decreases were found in overuse of specific time periods.
[b] Human papillomavirus.
[c] Sexually transmitted infection.

Table 3
Intervention studies, characteristics and key results.

Author (year)	Country	Study design	Limitations[a]	Intervention components	Sample size[b]		Data collection periods		Key results
Broach et al. (2014)	U.S.	Before-after study; no control or comparison group	8	Updates to EHRs	Pre	1709 HPV tests	Pre	1/2010–6/2010	Decrease in overuse (proportion of HPV tests among women under 21 significantly decreased)
					Post	1678 HPV tests	Post	7/2010–12/2010	
Hills et al. (2015)	U.S.	Before-after study; no control or comparison group	5	Clinical decision support Provider education Clinical procedure manual	Pre	1032 patients	Pre	6/1/2012	Significant decrease in overuse (proportion of screening too frequently)
					Post	1032 patients	Post	6/1/2013	
Schwaiger et al. (2013)	U.S.	Before-after study; no control or comparison group	7	Provider education	Pre	119 charts	Pre	10/1/2010–10/31/2010	Significant decrease in overuse ("early" pap tests)
				Pocket guide	Post	102 charts	Post	10/1/2011–10/31/2011	
White (2014)	U.S.	Before-after study; no control or comparison group	9	Updates to EHRs	Pre	759 patients	Pre	1/2010–12/2010	Significantly decrease in overuse (pap tests in women under 21)
					Post	1274 patients	Post	1/2011–9/2011	
White & Kenton (2013)	U.S.	Before-after study; no control or comparison group	9	Updates to EHRs	Pre	229 pap tests	Pre	1/2010–6/2010	Significant decrease in overuse (co-tests and pap tests in women under 21)
					Post	151 pap tests	Post	7/2010–12/2010	

[a] 21 possible limitations; adapted from the Task Force on Community Preventive Services data collection instrument for systematic reviews.
[b] Only one intervention study, Hills et al. 2015, used a matched sample for the pre-and post- intervention measurements.

two studies that found patient age was a significant predictor had conflicting results: one reported higher overuse among 30–50 year olds compared to older groups, while another study reported lower overuse among 35–64 year olds compared 24–34 year olds.

Correlates of overuse defined as cervical cancer screening after a hysterectomy were younger patient age, at least one contraceptive management visit, no depression or diabetes, and advanced practice nursing or gynecology provider.

Correlates of overuse defined as starting screening *before* the recommended age included older patient age, being born in the U.S., a prior cervical cytology being performed, the clinic being gynecologic where screening took place, more clinical visits, health insurance (varied by study), history of cervical intraepithelial neoplasia, use of hormonal contraception, previous HPV vaccination, primary language being Spanish, higher mother education, multiple sexual partners and previous sexual activity, pregnancy in the last 12 months, race (white), coming for a routine care visit, residing in an non-urban residence, and time (overuse decreased over time).

Correlates of overuse defined as continuing screening *after* the recommended age to stop screening were older patient age, no chronic disability, previous visit to the OBGYN, higher education, having health insurance, good/excellent health status, Hispanic ethnicity, race (black), lower education, having a hysterectomy (negatively), location (metropolitan area and south region of U.S.), lower mortality risk, low provider knowledge, former smoker, time (overuse decreased over time), and having a usual source of care.

3.2. Effectiveness of interventions

The search identified 5 intervention studies. All intervention studies used before-after designs with no comparison or control groups, had durations of 12 months or less, and were limited to one location or clinic (Table 3). All intervention studies reported decreases in overuse of cervical cancer care over time. However, intervention studies had substantial limitations (median = 7.6 limitations, range 5–9).

The most often-reported interventions were updates to electronic health records (EHR), reported in three intervention studies (White and Kenton, 2013; White, 2014; Broach et al., 2014). EHR updates included revising the language of the EHR forms (e.g., stating that HPV testing was not appropriate for women under 30 years old), setting automatic alerts when a test was requested for an individual outside the recommended parameters (e.g., Pap test is ordered for women under 21 years old), and providing a link to a website with more information about guidelines. Two intervention studies evaluated the effects of provider education on current screening guidelines and making changes to the EHR system (Hills et al., 2015; Schwaiger et al., 2013). Other intervention studies included manual or pocket guides to help guide providers determine the appropriate screening for a patient (Hills et al., 2015; Schwaiger et al., 2013). One intervention study provided clinical decision support, which included having a person in the clinic review patient charts to determine when patients were due for screening (Hills et al., 2015). None of the intervention studies included patient education or patient decision-making components for decreasing overuse.

4. Discussion

Our systematic review sought to identify correlates of overuse of cervical cancer screening and interventions that could decrease overuse of cervical cancer screening. The use of varied designs, variables measured, and analysis strategies do not lead to clear or definitive conclusions. However, a few findings emerged in multiple studies. With respect to correlates, overuse of cervical cancer screening has been decreasing over time across several measures; however, overuse is still prevalent. Screening at a gynecology practice was often associated with greater overuse (Tsui et al., 2014; Summers et al., 2015; Guo et al., 2015; Almeida et al., 2013) as was greater number of clinical visits

(Tsui et al., 2014; Almeida et al., 2013). Several studies reported a decrease in overuse among older patients, particularly for too-frequent screening (Arbyn et al., 1997; Barbadoro et al., 2015; Almeida et al., 2013) and after the recommended age to stop screening of 65 years among women with a history of normal screening results (Guo et al., 2015; Royce et al., 2014). However, for studies examining screening before the recommended starting age of 21 years, older patient age was associated with overuse (Henderson et al., 2013; Tsui et al., 2014).

More than half of U.S. women who reported having a hysterectomy also reported having an unnecessary Pap test following their hysterectomy, and approximately half of women ages 65 years and older reported receiving a Pap test within the past three years, in an analysis of National Health Interview Survey data (Kepka et al., 2014). In addition, younger patient age, Hispanic and Black race/ethnicity, income exceeding 400% of poverty level, and private health insurance coverage were associated with receipt of a recent Pap test after a hysterectomy (Kepka et al., 2014), indicating that these may be thus targets for interventions to reduce overuse.

One of the inherent issues of screening programs is the presence of false-positive screening results. False-positive results from excessive cervical cancer screening can result in costly, painful, and stressful colposcopies and biopsies among women who are unlikely to develop invasive cancer (Korfage et al., 2012; Welch and Black, 2010). Excisional procedures (i.e., LEEP/LLETZ or cold knife conization) may lead to short- and long-term health effects. Some evidence suggests that excisional procedures may increase chances of preterm delivery leading to higher neonatal morality (Sawaya et al., 2015). Because most low-grade cervical precancerous lesions clear spontaneously in younger age women, increasing the age of the first Pap test from 18 to 21 years has yielded substantial cost savings, with small differences in discounted average quality adjusted life expectancy (Sawaya et al., 2015).

With respect to interventions, strategies to reduce overuse focused mostly on providers and systems including provider education and EHR updates noting the appropriateness of screening for different age groups. As Pap testing is often initiated by the woman or health care provider, it is important that strategies address both the provider and the patient (Nayar et al., 2014; Arbyn et al., 2014; Makkonen et al., 2017). No strategies specifically targeted patients which may lead to confusion if the patients were not aware of revised clinical guidelines, and even mistrust if they viewed their providers as not providing adequate care (Allen et al., 2013). None of the intervention studies published to date examined patient preferences regarding cervical cancer screening, or included options for a patient-centered approach to shared decision making regarding de-escalation of cervical cancer screening. These approaches to engaging patients – which may help them to reflect on their values, understand the potential harms, and reduce screening overuse – have been recommended for other types of cancer screening, e.g., colorectal cancer screening and PSA testing (Li et al., 2013; Hoffman et al., 2010). It could be argued that they are less relevant for cervical cancer screening, but the emergence of HPV co-testing as an option might make shared decision making more applicable.

A comprehensive intervention strategy aimed at patients, providers, and systems may hold the most promise for improving adherence to the new guidelines. Providers' nonadherence to the new cervical cancer screening recommendations is high, ranging from 38% (King et al., 2014) to 61% (Teoh et al., 2015) in some studies. Providers have reported that the barriers to following USPSTF recommendations were patient concerns, provider disagreement with revised recommendations, concern about the risk of malpractice lawsuits, and limited time to discuss risk and benefits of low value screening with patients. Awareness alone does not seem to address nonadherence given that healthcare providers' awareness of the recommendations did not always lead to higher adherence. Provision of education focusing on patients' needs and wants, as well as harmonizing patients' and providers' knowledge of new screening recommendations may be conducive to more effective patient-provider communication around the changing recommendations (Pelzang, 2010).

Systems approaches, such as updating the EHR with accurate information about revised screening guidelines, were used in three intervention studies in our review. The EHR has emerged as an important tool for understanding patients' medical history, creating care-summary documents, developing and providing education materials for patients, performing care reconciliation, and submitting key data electronically to public health entities (Jha, 2010). Future research may explore leveraging this tool for patient education, provider's feedback and reminders, as well as clinic-level adherence tracking.

Findings from our review should be viewed in the context of the substantial limitations of the available published literature. Too few observational studies examined the same correlates and outcomes to make firm conclusions, and quantitative synthesis of pooled data across studies was not possible. No intervention studies used control or comparison groups. Given the decrease in overuse over time in observational studies, the putative intervention effects may well reflect secular trends or attention effects. Studies were conducted primarily in the U.S., and their findings' generalizability to other countries is unknown.

5. Conclusions

Overuse of cervical cancer screening is declining but remains prevalent (Watson et al., 2000–2010; Henderson et al., 2013; Tsui et al., 2014; Royce et al., 2014; Kale et al., 2013). Additional research is needed to understand the specific factors that account for the observed discrepancy between current cervical cancer screening recommendations and reported screening practices. Further, additional well-designed research is needed to rigorously evaluate interventions directed at patients, providers, and clinical systems to reduce overuse of cervical cancer screening.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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Appendix A. Search terms

1. The systematic search used the following MeSH terms and keyword combinations for all databased except CINAHL which required slight adjustments. The search included cervical cancer screening tests as well as other cancer screening tests as the original scope of the study was broader and later revised to only include cervical cancer screening test (“Health Services Misuse” OR overuse OR over-use OR overscreen* or over-screen* OR overutiliz* OR over-utiliz* OR “Patient Acceptance of Health Care” OR “Health Knowledge, Attitudes, Practice” OR “Physician Practice Patterns” OR “Guideline Adherence” OR nonadhere* OR “non-adhere*” OR noncompliance OR non-compliance OR compliance OR “low-value care” or “low value care” OR “Unnecessary Procedure*”)

2. AND (“Early Detection of Cancer” OR “cancer screening*”)
3. AND each of the following combination of terms:
   a. (“uterine cervical neoplasms” OR “cervical neoplasms” OR “cervical cancer” OR “cervix cancer”) AND (“papanicolaou test*” OR “Human Papillomavirus DNA Test*” OR “human papillomavirus test*” OR “HPV test*” OR “HPV DNA test*” OR “pap smear*” OR “pap test*” OR “cervical smear*” OR “smear test*”);
   b. (urinalysis OR cystoscopy OR “urine cytology” OR “hematuria test*” OR “Urine tests for tumor markers” OR UroVysion OR “BTA test*” OR “Immunocyt” OR “nuclear matrix protein 22” OR “NMP22 BladderChek”) OR (“urinary bladder neoplasms” OR “bladder neoplasms” OR “bladder tumor” OR “bladder cancer”);
   c. (“Genes, BRCA1” OR “BRCA1 Gene” OR “FANCD1 protein” OR “fanconi anemia complementation group D1 protein” OR “fanconi anemia group D1 protein” OR “BRCA2 Gene Product” OR “Breast Cancer 2 Gene Product” OR “fanconi anemia group D1 complementing protein” OR “breast cancer 2 protein” OR “Genetic Testing” OR genetic test* OR “genetic counseling” OR “risk assessment”) AND (“Breast Neoplasms” OR “breast neoplasms” OR “breast cancer”);
   d. (Mammography OR mammographies OR mammogram OR mammograms OR “Breast Self-Examination” or “breast self-exam*” or “breast self exam*” OR “digital mammography” OR “digital mammographies” OR “digital mammogram” OR “digital mammograms” OR “magnetic resonance imaging” OR MRI OR “clinical breast exam*” OR “breast exam*”) AND (“breast neoplasms” OR “breast cancer”);
   e. (“colorectal neoplasms” OR “colon cancer” OR “colorectal cancer” OR “colorectal polyps” OR “colorectal tumor*”) AND (colonoscopy OR colonoscopies OR “colonoscopic surgery endoscope” OR endoscopy OR endoscopies OR endoscopic OR Sigmoidoscopes OR sigmoidoscope OR sigmoidoscopy OR proctosigmoidoscope OR proctosigmoidoscopes OR “double-contrast barium enema” OR “high-sensitivity fecal occult blood test*” OR FOBT OR “fecal immunochemical test*” OR FIT OR “fecal immunochemical test*” OR “stool DNA test*” OR “fecal DNA test*” OR “computed tomographic colonography” OR “CT colonography” OR “virtual colonoscopy”);
   f. (“mouth neoplasm*” OR “oral neoplasm*”OR “mouth cancer” OR “oral cancer”) AND (“oral cancer screening*” OR “Toluidine blue stain” OR “Fluorescence staining” OR “Exfoliative cytology” OR “Brush biopsy”);
   g. (“ovarian neoplasm*” OR “ovary neoplasm*” OR “ovary cancer” OR “ovarian cancer”) AND (“ovarian cancer screening*” OR “Gynecological Exam*” OR “vaginal exam*” OR “pelvic exam*” OR “Transvaginal ultrasound” OR TVU OR “CA-125 assay”);
   h. (“pancreatic neoplasm*” OR “pancreas neoplasm*” OR “pancreatic cancer” OR “pancreas cancer”) AND (“abdominal palpation*” OR “abdominal exam*” OR ultrasonography OR Ultrasound* OR ultrasonic OR sonography OR “serologic marker*” OR “pancreatic cancer screening” OR “pancreas cancer screening”);
   i. (“prostatic neoplasm*” OR “prostatic cancer” OR “prostate cancer”) AND (“prostate cancer screening*” OR “prostate-specific antigen-based screening*” OR “PSA-based test*” OR “PSA blood test*” OR “prostate specific antigen test*” OR PSA OR “PSA Test*”);
   j. (“skin neoplasm*” OR “skin cancer” OR melanoma* OR “cutaneous melanoma*” OR “basal cell neoplasm*” OR “basal cell cancer” OR “squamous cell skin cancer” OR “squamous cell carcinoma”) AND (“self-exam*” OR “self exam*” or “whole-body skin exam*” OR “skin exam*”);
   k. (“testicular neoplasm*” OR “testicular tumor*” OR “testis neoplasm*” OR “tumor of testis” OR “testis tumor*” OR “cancer of testis” OR “testis cancer” OR “testicular cancer”) AND (“self-exam*” OR “self exam*” OR “physical exam*” OR “testicular cancer screening” OR “testis cancer screening”)

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