Review

Cancer Epidemiology, Biomarkers & Prevention

Mobile Screening Units for the Early Detection of Cancer: A Systematic Review

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Abstract

Mobile screening units (MSUs) provide cancer screening services outside of fixed clinical sites, thereby increasing access to early detection services. We conducted a systematic review of the performance of MSUs for the early detection of cancer. Databases (MEDLINE, EMBASE, Cochrane Library, WHO Global Health Library, Web of Science, PsycINFO) were searched up to July 2015. Studies describing screening for breast, cervical, and colon cancer using MSUs were included. Data were collected for operational aspects including the performance of exams, screening tests used, and outcomes of case detection. Of 268 identified studies, 78 were included. Studies investigated screening for cancers including breast ($n = 55$), cervical ($n = 12$), colon ($n = 1$), and multiphasic screening for multiple cancers ($n = 10$). The median number of screening exams performed per intervention was 1,767 (interquartile range 5,656–38,233). Programs operated in 20 countries, mostly in North America (36%) and Europe (36%); 52% served mixed rural/urban regions, while 35% and 13% served rural or urban regions, respectfully. We conclude that MSUs have served to expand access to screening in diverse contexts. However, further research on the implementation of MSUs in low-resource settings and health economic research on cost-effectiveness of MSUs compared with fixed clinics to inform policymakers is needed. *Cancer Epidemiol Biomarkers Prev; 26(12); 1679–94. ©2017 AACR.*

Introduction

The implementation of screening and early detection programs is a cornerstone of cancer prevention (1, 2). Despite evidence that early detection saves lives, global disparities in access to services persist (1). Barriers to cancer screening include lack of provider availability, community access to screening and community demand for screening (3). Challenges related to health care providers can include shortages in screening delivery or policies that require a referral from a family physician to access screening. Community access to screening can be limited by prohibitive costs or inaccessibility of screening clinics due to distance, hours of operation, or a lack of knowledge about where to go for screening. Finally, client demand for screening can pose as a barrier in situations where individuals are unaware of the benefits of screening, do not perceive themselves at risk, or fear screening results.

Mobile screening units (MSUs) are an innovative alternative to screening exams in clinics or hospitals and may include vans, recreational vehicles, or other traveling clinics that are staffed by health workers and outfitted with equipment for early detection. MSUs allow care providers to increase their capacity for service delivery outside of fixed clinics, which is particularly important in areas without an infrastructure for cancer screening services (4). MSUs increase community access by offering screening in convenient locations thus decreasing the distance and travel time needed to access screening services (5). MSUs also present unique challenges for service delivery, such as more complicated referral systems as individuals with abnormal exams commonly need to report to a specialty clinic for follow-up.

Previous narrative literature reviews of community-based screening initiatives have concluded that eliminating structural barriers such as location, distance, and inconvenient hours of operation is highly effective in increasing screening in high-income countries (3, 5). In 1995, a National Cancer Institute survey of 1,057 mammogram facilities in the United States showed that 2.4% of screening services were offered in MSUs, which demonstrated similar quality indicators as fixed clinics with respect to certification of personnel, quality control practices, and frequency of equipment verification by medical physicists. In addition, the NCI survey found MSUs benefitted clients by offering lower fees, accessible evening operating hours, and serving a higher proportion of self-referred women (4). A survey on barriers to breast and cervical cancer screening among underserved populations in the United States found MSUs to be an effective strategy for reaching women over the age of 60 years, some of whom may be unable to travel to fixed clinics (6). Overall, current evidence to support the operations of MSU programs is limited, with summaries available only through dated reviews (6–8) and informal medical forums (9). In addition, none of the prior reviews included data on performance measures, such as recall rates and case detection rates.

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To our knowledge, no systematic review has synthesized results on the implementation of MSU programs. This systematic review summarizes the evidence from qualitative, quantitative, and mixed-method studies on the implementation of MSUs for early cancer detection worldwide.

Materials and Methods

Inclusion criteria

We adhered to the PRISMA guidelines and followed a review protocol (10). Empirical studies that included a description of cancer screening for breast, cervical, and colorectal cancer taking place on MSUs were eligible for inclusion. No restrictions were placed on study design, study location, and participants. Studies reporting on screening tests to detect precancerous lesions or early invasive cancer were eligible. Both organized and opportunistic screening programs were included. Only studies published in English, French, or Portuguese were considered. Studies were excluded if data on the MSU program were not reported separately from those of a fixed clinic.

The following databases were searched through to July 2015: EMBASE (via Ovid), MEDLINE and PubMed (via Ovid), Cochrane Library, WHO Global Health Library, Science Citation Index Expanded (via Web of Science), Social Sciences Citation Index (via Web of Science), and PsycINFO (via Ovid). Additional studies were identified through bibliographies of included studies and consulting subject matter experts. The search strategy was developed by a medical librarian and used the following search terms to query databases: mobile, movable, traveling, unit, clinic, facility, hospital, early detection, neoplasms, cancer screening, cancer prevention, and cancer diagnosis. A full search strategy is included in Supplementary Table S1. Only published articles in peer-reviewed journals or thesis dissertations were included. Conference abstracts/posters, review articles, and opinion pieces were excluded.

Study selection and data collection process

We first reviewed titles and abstracts of potentially relevant citations. The full text of eligible articles was then screened by one author and verified by a second. Disagreements between authors were resolved by discussion or consultation with a third author. Reasons for the exclusion of full-text articles were recorded.

Two authors then independently reviewed full-text articles. Data were extracted onto a piloted comprehensive and standardized data abstraction sheet by one author and validated by a second author. The following information was extracted: study design, country, cancer site(s), screening test(s), size of target population, number of screening exams and/or number of individuals screened, participant sociodemographic characteristics, type of MSU, operational characteristics of MSU (with respect to the number of screening tests offered, daily kilometer distance traveled, locations of follow-up facilities, etc.) and performance measures of screening including the rate of abnormal calls, biopsy rate, losses to follow-up, timeliness of follow-up, number of detected cases, and characteristics of detected cases including staging and extent of disease. Test validity measures including sensitivity, specificity, positive predictive value, and negative predictive value were extracted when reported or otherwise manually calculated (formulas provided in Supplementary Table S2). We considered screening programs to be organized if they were part of a systematic program where every individual in a target population was invited to attend screening.

We collected economic data when reported; however, no analyses were conducted due to the broad time range of included studies and nontransferability of costs of medical equipment and infrastructure from past to present. If key data were missing from studies, we contacted the investigators of original studies published within the last 10 years to obtain the information. Where multiple reports of the same study were published, we extracted data from the most recent or comprehensive publication.

The risk of bias for a subset of individual studies reporting detected cancer cases was independently appraised by two authors using the Mixed Methods Appraisal Tool (MMAT; ref. 11) provided in Supplementary Table S3. This tool was selected for its capacity to appraise quantitative, qualitative, and mixed-method studies. The content validity and reliability of the MMAT for judging methodologic quality has been previously validated (12). We rated each study according to four criteria via a score ranging from 100% (all criteria met) to 0% (no criteria met). MMAT methodologic criteria indicators vary by study design to assess systematic error such as sampling, selection, confounding, and information biases. Conflicts were resolved by consensus or consultation with a third author. We modified the tool to include a criterion to assess the methodologic quality of screening programs for studies using a quantitative descriptive design without comparison group. The modified criterion assessed whether the rate of follow-up among abnormal screening exams was above 80%. We used an 80% threshold as this has been previously established by WHO early detection programme guidelines as a minimum acceptable rate of follow-up (2). In addition, we hypothesized that loss to follow-up among abnormal screening exams would introduce information bias into studies, leading to an underestimation of case detection rates.

Summary measures

Because of the heterogeneity in study endpoints and the presence of noncomparative study designs, the studies were not amenable to statistical analyses and no meta-analysis was possible. Studies were thus summarized qualitatively in terms of key study characteristics, such as the number of screening exams performed on MSUs, and duration of program operations, and performance outcomes including the rate of abnormal calls, biopsy rate, number of detected cases, and characteristics of detected cases, without an overall summary effect measure. Outcomes were graphically displayed for continuous data, such as the performance of programs in terms of case detection rates per 1,000 screening exams.

The implementation of the MSU programs are described with respect to three evidence-based factors associated with successful delivery of population-based screening services: provider delivery, community access, and community demand (3). We also summarized available information on the referral systems of MSU programs and reported rates of loss to follow-up following abnormal exams.

Results

The initial search yielded 441 articles. An additional 27 records were identified through other sources. After checking for duplicates, there were 268 unique hits. Careful analysis of titles and abstracts resulted in 140 eligible articles. Of these, 78 studies met

the inclusion criteria and were included in the review (Fig. 1; Table 1). Twelve studies were excluded due to screening for sites of cancer for which current evidence does not support efficacy of screening among the general population, such as for skin cancer ($n = 5$), lung cancer ($n = 3$), gastric cancer ($n = 2$), oral cancer ($n = 1$) and prostate cancer ($n = 1$). Key operational aspects of these MSU studies are summarized in Supplementary Table S4.

Study characteristics

The majority of MSU interventions ($n = 55$) targeted breast cancer while other studies involved cervical cancer ($n = 12$), colon cancer ($n = 1$), or multiphasic screening for multiple cancer sites ($n = 10$). A summary of operational measures by site of cancer screening is presented in Table 2. Studies were published between 1970 and 2016 and were conducted in 20 countries, with the majority from Europe (36%), North America (36%), Latin America (13%), and Asia (11%); 52% of MSUs offered services in both rural and urban areas, while 35% of programs exclusively served rural regions and 13% exclusively urban areas. Overall, 28% of studies were part of organized screening programs.

Study designs, based on the classifications for mixed study designs (11), are reported in Table 1. The majority were of a quantitative descriptive nature (64% including 50 single-group studies of cancer incidence/prevalence or operational measures and three studies of cost-effectiveness); a further 22% were

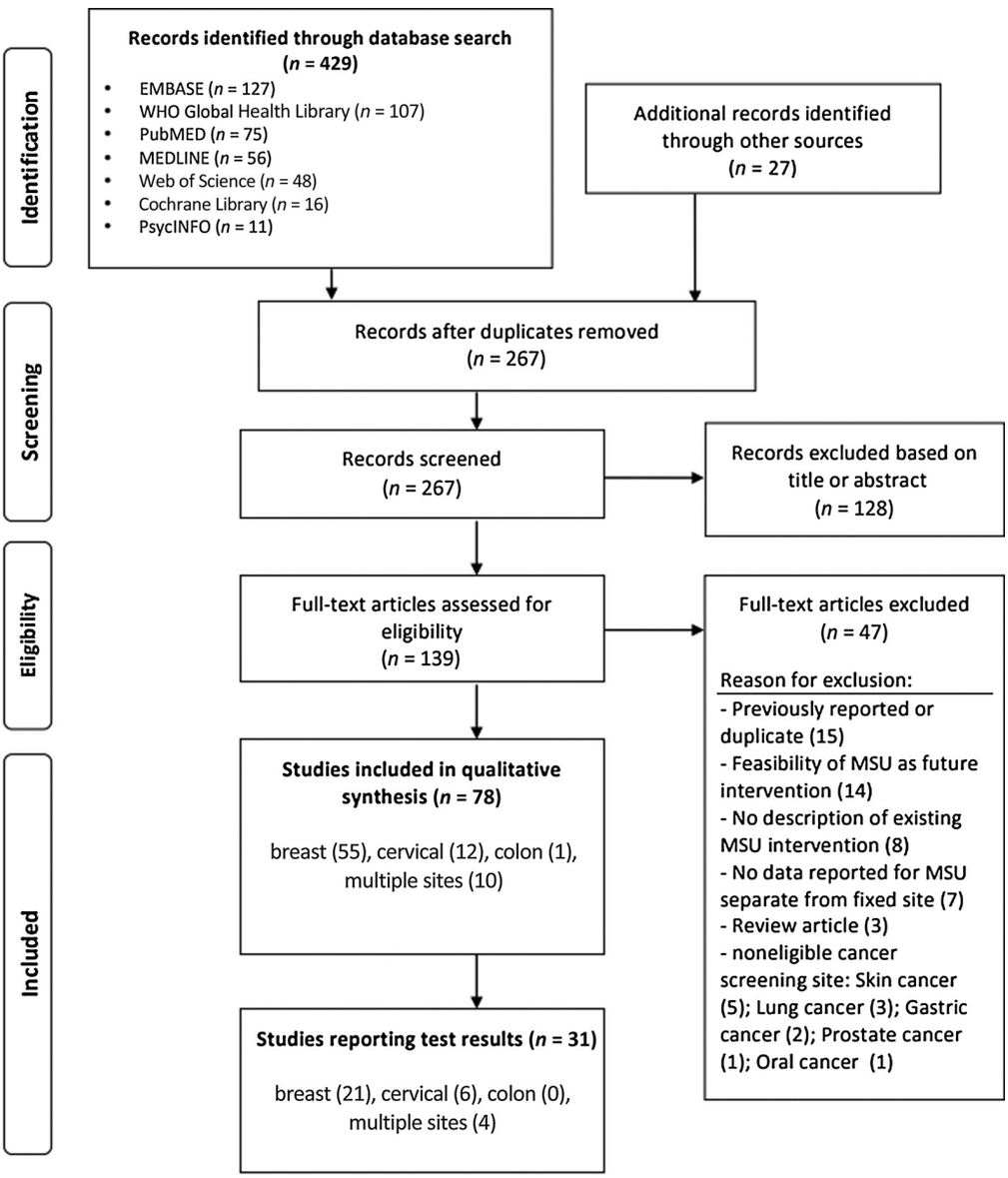

Figure 1.
PRISMA flow diagram of studies for inclusion.

Table 1. Line listing of included studies by cancer site

Site of cancer	Study authors, publication year	Country	Screening test	Study length years	Number of MSU exams	Study design[a] case detection reported
Breast cancer	Reuben, 2002 (37)	USA	Mammogram (NOS)	2	129	RCT
	Rimer, 1992 (59)	USA	Mammogram (NOS)	—	—	RCT
	Williams, 1989 (77)	UK	Mammogram (NOS)	—	316	RCT
	Tabar, 1981 (22)	Sweden	Film mammogram	2.3	34,187	RCT[a]
	Strax, 1973 (23)	USA	Film mammogram, CBE	5	20,211	RCT[a]
	Hughes, 2014 (13)	Australia	Film mammogram	9	214,328	Prospective cohort[a]
	Mizuguchi, 2014 (53)	USA	Digital, film mammogram	10	48,324	Prospective cohort[a]
	Horton, 1996 (66)	UK	Film mammogram	0.5	4,578	Prospective cohort
	Roen, 2013 (33)	USA	Digital mammogram	2	1,771	Retrospective cohort
	Del Turco, 2007 (18)	Italy	Digital, film mammogram	1.8	28,770	Retrospective cohort[a]
	Zappa, 2002 (76)	Italy	Film mammogram	9	80,134	Retrospective cohort[a]
	Fayanju, 2014 (34)	USA	Mammogram (NOS)	5	7,334	Cross-sectional
	Fontenoy, 2013 (14)	Canada	Digital, film mammogram	8	42,279	Cross-sectional[a]
	Van Hal, 1999 (78)	Belgium	Mammogram (NOS)	0.2	—	Cross-sectional
	Stark, 1997 (28)	UK	Mammogram (NOS)	—	—	Cross-sectional
	Orton, 1991 (46)	UK	Mammogram (NOS)	1	1,408	Cross-sectional
	Séguret, 1995 (72)	France	Film mammogram	2.5	26,026	Cross-sectional[a]
	Roberson, 1994 (63)	USA	CBE	—	271	Cross-sectional
	Al Mulhim, 2015 (69)	Saudi Arabia	Digital mammogram	5	8,061	Descriptive
	Apffelstaedt, 2014 (31)	South Africa	Digital mammogram	1.5	2,712	Descriptive[a]
	Renck, 2014 (16)	Brazil	Mammogram (NOS)	—	9,919	Descriptive[a]
	Brooks, 2013 (42)	USA	Digital mammogram, CBE	2	4,543	Descriptive[a]
	Carkaci, 2013 (17)	USA	Digital, film mammogram	20	6,776	Descriptive[a]
	Haikel, 2013 (30)	Brazil	Film mammogram	2	10,521	Descriptive[a]
	Lee, 2013 (79)	Taiwan	Mammogram (NOS)	0.3	—	Descriptive
	Vyas, 2013 (44)	USA	Digital mammogram	2	1,161	Descriptive
	Bond, 2009 (41)	UK	Mammogram (NOS)	3	39,260	Descriptive
	Rodriguez-Cuevas, 2009 (71)	Mexico	Film mammogram	1.5	96,828	Descriptive[a]
	Copeland, 2008 (45)	USA	Mammogram (NOS)	1	3,336	Descriptive
	Peek, 2007 (43)	USA	Mammogram (NOS)	1.5	—	Descriptive
	Maheswaran, 2006 (39)	UK	Mammogram (NOS)	3	16,695	Descriptive
	Lane, 2003 (51)	USA	Mammogram (NOS)	—	141	Descriptive
	Tinkler, 2001 (80)	UK	Mammogram (NOS)	0.7	—	Descriptive
	Gordenne, 2000 (78)	Belgium	Mammogram (NOS)	8	52,475	Descriptive[a]
	Frelix, 1999 (35)	USA	Film mammogram, CBE	1.1	1,935	Descriptive[a]
	Swaddiwudhipong, 1999 (81)	Thailand	CBE	1	—	Descriptive[a]
	Kann, 1998 (82)	USA	Film mammogram, CBE	5	19,280	Descriptive[a]
	Schweitzer, 1998 (83)	USA	Film mammogram	3	10,859	Descriptive
	Falshaw, 1996 (32)	UK	Mammogram (NOS)	—	338	Descriptive
	Kohli, 1995 (40)	UK	Mammogram (NOS)	1	11,425	Descriptive
	Sutton, 1995 (65)	UK	Mammogram (NOS)	0.3	306	Descriptive
	Van Oyen, 1994 (74)	Belgium	Mammogram (NOS)	3	16,017	Descriptive[a]
	Garas, 1994 (73)	Greece	Film mammogram	—	22,258	Descriptive[a]
	McCoy, 1992 (36)	USA	Film mammogram	4.3	16,354	Descriptive[a]
	Dershaw, 1992 (55)	USA	Film mammogram	3	22,540	Descriptive[a]
	Kessler, 1991 (56)	USA	Film mammogram	1.1	3,627	Descriptive
	Williams, 1990 (84)	UK	Film mammogram	4	6,409	Descriptive
	Rubin, 1990 (85)	USA	Film mammogram	0.5	2,099	Descriptive
	Haiart, 1990 (68)	UK	Film mammogram	0.5	6,080	Descriptive
	Kettlehake, 1988 (57)	USA	Film mammogram	0.9	5,000	Descriptive
	Hamilton, 2003 (62)	UK	Mammogram (NOS)	—	—	Qual. descriptive
	Scammon, 1991 (38)	USA	Mammogram (NOS)	—	—	Qual. descriptive
	Kennedy, 2009 (60)	USA	Mammogram (NOS)	2	—	Case study
	Nielsen, 1991 (86)	USA	Mammogram (NOS), CBE	—	~8,000	Case study
	Kluhsman, 2009 (52)	USA	Film mammogram	18	4,606	Descriptive
Cervical cancer	Fregnani, 2013 (27)	Brazil	Pap, Pap-LBC	0.6	12,048	Cross-sectional[a]
	Megevand, 1996 (15)	South Africa	Pap, VIA	0.7	5,045	Prospective cohort[a]
	Lorenzi, 2016 (21)	Brazil	HPV testing, Pap-LBC	0.8	3,068	Descriptive[a]
	Ferris, 2015 (26)	Peru	Pap	2	1,700	Descriptive
	Cheng, 2014 (87)	Taiwan	Pap	5	85	Descriptive
	Paengchit, 2014 (25)	Thailand	HPV testing, Pap-LBC	0.3	2,000	Descriptive[a]
	Riza, 2000 (88)	Greece	Pap	9	19,961	Descriptive
	Swaddiwudhipong, 1999 (20)	Thailand	Pap	4	—	Mixed-methods: Descriptive[a]
	Thornton, 1989 (54)	UK	Pap, CBE	0.5	568	Descriptive[a]
	Brindle, 1976 (49)	UK	Pap	0.1	1,526	Descriptive[a]

(Continued on the following page)

Table 1. Line listing of included studies by cancer site (Cont'd)

Site of cancer	Study authors, publication year	Country	Screening test	Study length years	Number of MSU exams	Study design[a] case detection reported
	Whitfield, 1972 (50)	UK	Pap	3	1,952	Descriptive[a]
	Logan, 2011 (61)	Ireland	Pap	—	—	Case study
Colon	Bruwer, 2013 (29)	South Africa	Colonoscopy	2	—	Case study
Multiple sites	Schnippel, 2015 (89)	South Africa	Breast and cervical cancer: CBE, Pap and VIA	1	1,756	Cost-effectiveness
	Mauad, 2009 (70)	Brazil	Breast and cervical cancer: Film mammogram, Pap	1	7,192, 2,964	Descriptive[a]
	Alexy, 1998 (90)	USA	Breast, Cervical: CBE, Pap	—	—	Descriptive
	Craddock, 1975 (91)	UK	Breast, cervical: Mammogram (NOS), Pap	—	—	Descriptive
	Seacome, 1971 (92)	UK	Breast, Cervical: CBE, Pap	0.5	—	Descriptive
	Whitfield, 1970 (93)	UK	Breast, Cervical: CBE, Pap	0.2	1,064	Descriptive
	Kumar, 2011 (24)	India	Breast, cervical and oral: CBE, VIA/VILI, OVE	0.3	182	Descriptive
	Yoon, 2009 (64)	Korea	Breast, cervical, gastric, liver, colon: MMG + CBE, Pap, upper GI series/ endoscopy, serum alpha fetoprotein tests and abdominal ultrasonography, FOBT	0.3	—	Cross-sectional
	Lynch, 1976 (94)	USA	Breast, cervical, prostate, gastric, oral, lung, colon: Tests unspecified	4	5,232 total	Descriptive[a]
	Lynch, 1973 (67)	USA	Breast, cervical, prostate, gastric, oral, lung, CRC, penile: Mammogram (NOS), CBE, Pap, DVI, OVE, indirect laryngoscopy, proctosigmoidoscopy	1	—	Descriptive[a]

Abbreviations: CBE, Clinical breast exam; DVI, Direct visual inspection; Pap, Papanicolau smear with conventional cytology; Pap-LBC, Papanicolau smear with liquid based cytology; NOS, not otherwise specified; OVE, oral visual examination; VILI, visual inspection with Lugol iodine.
[a]Studies report results for number of detected cases of cancer and/or test performance.

nonrandomized quantitative studies (including three prospective and four retrospective cohort studies, and 10 cross-sectional studies comparing outcomes between two groups); 6% were randomized control trials (RCT; $n = 5$) and 8% ($n = 6$) were qualitative descriptive or case studies.

As shown in Table 3, 32 studies reported performance measures. The quantitative descriptive studies ($n = 22$) measured various implementation, clinical and service-related outcomes, and generally explicitly or implicitly stated the objective of evaluating the performance of the MSU program. The nonrandomized observational studies ($n = 7$) sought to answer more specific questions, often with respect to comparisons in screening modalities such as the effectiveness of MSU as compared with fixed clinic screening (13–16); breast cancer studies comparing digital to film-screen mammography (17, 18); cervical cancer studies comparing conventional Pap cytology with liquid-based Pap cytology (Pap-LBC) tests (19, 20) or human papillomavirus (HPV) testing with Pap-LBC (21). Two RCTs for mammography screening sought to establish evidence of mortality reductions associated with screening (22, 23).

Quality review

The mean overall score was 74.2% for the 29 studies assessed for methodologic quality (Table 3), indicating a fair level of methodologic quality across studies. Trends in the risk of bias by study design are presented in Fig. 2. The overall quality score was 72% for the 22 descriptive studies (Fig. 2A) and 82% for the seven nonrandomized observational studies (Fig. 2B). A common weakness was incompleteness in reporting outcomes, with 50% of the descriptive studies and 29% of nonrandomized observational studies providing no information on follow-up rates. Two RCTs for breast cancer received scores of 100% (22) and 50% (23).

Screening tests by cancer site

Fifty-five studies described breast cancer screening using a range of tests including digital or analog film-screen mammography and clinical breast exams. In addition, all 10 multiphasic programs offered breast screening. The number of mammography screening exams reported per study ranged from 141 to 214,327, and study duration ranged up to 20 years; this indicates the flexibility of MSUs to be used at various capacities in different

Table 2. Overall operational characteristics of included studies by cancer site

Site of cancer	Number of studies	Number screening exams per program: mean (min, max)	Region of operations (% rural, urban, mixed)	Percent organized screening, % (*n*)
Breast	55	21,223 (141–214,328)	24% rural/20% urban/56% mixed	40% (19)
Cervical	12	4,954 (85–19,961)	46% rural/54% both	17% (2)
Colon	1	—	100% rural	0%
Multiphasic	10	1,994 (182–5,232)	18% rural/9% urban/64% mix	18% (2)
Total	78	14,069 (85–214,328)	29% rural/10% urban/57% mix	28% (22)

Table 3. Descriptive summary of quality, performance indicators, and case detection rates

	Author, year, country,	Study design MMAT quality score	Description of intervention (study objective, target population, screening test, MSU type, time period of study)	Sample (number of clients screened or exams, demographics)	Reported cancer screening performance indicators	Cancer detection rate/1,000 exams
Breast cancer	Al Mulhim et al. (2015), Saudi Arabia (69)	Quantitative descriptive MMAT: 50%	Target: 53,800 women ≥ age 40 sampled from 15 primary care centers in Eastern Saudi Arabia Test: digital MMG; MSU type: 2 vans Period: 2009–2014 (5 years); opportunistic screen	8,061 clients screened; mean age (SD): 46.5 (9.4); age range: 37–78	Abnormal call rate: 7.9% ($n = 636$); biopsy rate: 0.7% ($n = 63$) Detected cases: $n = 47$; test PPV=7.3%[a]; biopsy PPV=74.6%[a] Proportion DCIS: 15%, 70.2% of cases <2 cm	5.9 (first round); 4.1 (later rounds)
	Apffelstaedt et al. (2014), South Africa (31)	Quantitative descriptive MMAT: 50%	Target: women ≥ age 40 served by primary health centers in Capetown Test: digital MMG; MSU type: 1 van Period: 2011–2012 (2 years); opportunistic screen	2,712 clients screened	Abnormal call rate: 9.6% ($n = 261$); biopsy rate: 1.2% ($n = 32$) Lost to follow-up among recalls: 4% ($n = 11$) Detected cases: $n = 10$ (5 DCIS, 2 stage II; 3 stage III) Test PPV = 3.8%[a]; biopsy PPV =31%[a]	3.7
	Hughes et al. (2014), Australia (13)	Retrospective cohort MMAT: 75%	Objective: to compare diagnostic effectiveness of MSU-MMG + step-down MSU assessment versus fixed-center (FC)-MMG + diagnostic follow-up Target: women ages 40–69 in Western Australia Test: MSU-MMG + "step down" follow-up of diagnostic views in MSU with referral to urban FC if biopsy is required; MSU type: 1 van Comparison: FC-MMG + FC diagnostic follow-up Period: 1999–2008 (10 years); organized program	MSU, FC group: number of exams 214,328, 545,699	Results reported for MSU, FC: screening uptake rate: 59%, 57%; repeat participation rates (within 27 mos.): 64.9% (64.7–65.1), 68.3% (68.2–68.4) Tumor size: 17.1 mm, 17.4 mm Interval cancer rates per 10,000 women: ≤12 months: 0.16 (0.02–0.34), 0.70 (0.46–0.94) 13–24 months: 0.54 (0.18–0.89), 0.76 (0.49–1.03) Sensitivity = 95%, 91%	3.1 (2.8–3.3) MSU group vs. 7.04 (6.82–7.27) FC group
	Renck et al. (2014), Brazil (16)	Cross-sectional analytic MMAT: 75%	Target: Women ≥ age 40 in southern Brazil Test: MSU-MMG; MSU type: 1 van Comparison: FC-MMG Period: unspecified; opportunistic screen	MSU, FC group: clients screened; 8,607, 1,312; mean age (SD): 51.2 (10.4), 51.4 (10.4); first-screen: 48%, 26%	Results reported for MSU, FC: Detected cases: $n = 37$, $n = 9$, odds of breast cancer detection is similar between MSU and FC: crude OR: 1.60 (CI: 0.77–3.32); adjusted OR for sociodemographic factors (1.56, CI: 0.73–3.31).	4.3 (MSU) 6.9 (FC)
	Carkaci et al. (2013), USA (17)	Quantitative descriptive MMAT: 75%	Target: women ≥35 years in Texas Test: film MMG (2009–10), digital MMG (2011–12); MSU type: 1 van Period: 2009–2012 (4 years); opportunistic screen	12,726 exams; 33% medically underserved population	Abnormal call rate = 16.2% (film) 15.8% (digital) Detected cases: not reported Operational measures: mean number of exams per day = 23 (film), 20 (digital); Mean daily kilometers = 42 km Total cost per MU = $427,103 (2013 USD)	2.3 (film, 2009), 2.9 (digital, 2011)
	Fontenoy et al. (2013), Canada (14)	Retrospective cohort MMAT: 100%	Objective: to compare diagnostic performance of MSUs to FCs Target: Women ages 50–69 in Québec Test: MSU-MMG (digital and film); MSU type: 2 vans, 1 portable unit transport by boat/plane Comparison: FC-MMG Period: 2002–2010 (9 years); results reported for 2002–2006; organized program	MSU, FC group: 16,654 exams, 1,000,706 exams; mean age (SD) = 57.9 (5.5), 58.0 (5.5)	MSUs coverage rate: 44.3% (2002–05), 63.4% (2006–10); first-screen (MSU): 11% Results of MSU, FC: abnormal call rate: 8.1% ($n = 1,354$), 9.5% ($n = 95,440$) Detected cases: $n = 72$, $n = 5,166$ Test sensitivity: 69.9%, 70.3%; Test PPV: 5.3%, 5.4% *No differences in validity measures between MSU and FC (compared using adjusted risk ratios with 95% CI)	4.3 (MSU) 5.2 (FC)

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Table 3. Descriptive summary of quality, performance indicators, and case detection rates (Cont'd)

Author, year, country,	Study design MMAT quality score	Description of intervention (study objective, target population, screening test, MSU type, time period of study)	Sample (number of clients screened or exams, demographics)	Reported cancer screening performance indicators	Cancer detection rate/1,000 exams
Brooks et al. (2013), USA (42)	Quantitative descriptive MMAT: 75%	Target: women ages 40–75 in Louisville, KY at "high risk" (regions with high cancer mortality and poverty) Test: digital MMG and CBE; MSU type: 1 van Period: 2008–2010 (3 years); opportunistic screen	3,923 clients screened (4,542 MMG, 4,516 CBE); mean age = 54.6; 29% $\geq$ 5 years since last exam	Abnormal call rate: 9.3% (n = 424)[a] Detected cases: n = 31; Test PPV: 7.3% (31/424)[a] Factors associated with abnormal exam: age (<50), no insurance, Hispanic ethnicity, smoking, and family history	7.9
Haikel et al. (2012), Brazil (30)	Quantitative descriptive MMAT: 75%	Target: women ages 40–69 in São Paulo state Test: film MMG; MSU type: multiphasic van (also offered Pap test for cervical cancer) Period: 2003–2005 (3 years); opportunistic screen	10,521 clients screened; mean age (SD) = 51 (7.8); First-screen: 42%	Abnormal call rate: 9.4%; biopsy rate: 2.6% Detected cases: n = 41; Test PPV: 4.5%; Biopsy PPV: 16% Operational measures: mean daily number of exams = 26.3	3.9
Rodriguez-Cuevas et al. (2009), Mexico (71)	Quantitative descriptive MMAT: 75%	Target: Women ages $\geq$40 residing in Mexico City's Federal District Test: film MMG; MSU type: 7 vans Period: 2005–2006 (2 years); opportunistic screen	96,828 clients screened; Mean age (SD) = 49.3 (8.5)	Abnormal call rate: 1% (n = 949) Loss to follow-up among abnormal exams: 21% Detected cases: n = 208; Test PPV = 27.7% (208/949)[a] Proportion of cases detected *in situ* or stage I = 29.4%	2.1
Del Turco et al. (2007), Italy (18)	Retrospective cohort MMAT: 75%	Study objective: compare performance measures of digital and film MMGs (both offered on MSU) Target: Women ages 50–69 residing in Florence Test group: digital MMG; Comparison group: film MMG (matched by age and radiologist) MSU type: 2 vans Period: 2004–2005 (2 years); organized program	Digital, film group: Clients screened: n = 14,385, n = 14 385 First-screen: 12.2%, 11.8%	Results of digital, film group: Abnormal call rate: 4.3% (n = 618), 3.5% (n = 498) Recall rate (poor quality): 0.3% (n = 39), 0.5% (n = 72) Detected cases: n = 104, n = 84 Test PPV: 15.9%, 14.7% Proportion DCIS: 27.8% (n = 29), 17.8% (n = 15) χ^2 tests showed difference between groups*	Digital, film: 7.4, 8.2 (first round) 7.2, 5.5 (repeat rounds)
Zappa et al. (2002), Italy (76)	Quantitative descriptive MMAT: 75%	Study objective: To monitor the occurrence of interval breast cancers Target: Women ages 40–70 (1970–1990); ages 50–70 (post 1990) in the district of Florence Test: film MMG; MSU type: 1 van Period: 1985–1993 (9 years); organized program	80,134 exams: (13,153 first round, 66,981 repeat rounds)	Detected cases: n = 277 Proportion of screen-detected *in-situ*: 6.5% (18/277) 90 incidence cases detected $\leq$3 years after negative exam Breast density was associated with increased risk of developing interval case	4.9 (first round) 3.17 (repeat rounds)
Gordenne et al. (2000), Belgium (78)	Quantitative descriptive MMAT: 50%	Target: 99,699 women ages 40–69 residing in the province of Liège Test: film MMG; MSU type: 3 vans Period: 1992–1998 (8 years); organized program	52,475 exams (29,918 clients screened)	Mean attendance rate = 25%; abnormal call rate: 3.3% (n = 1,012); recall rate (poor quality): 0.7% (n = 343) Detected cases: n = 207; Test PPV: 20.5%[a] Proportion DCIS: 16% (n = 30); tumors <10 mm: 36% (n = 70)	3.9[a]

(Continued on the following page)

Table 3. Descriptive summary of quality, performance indicators, and case detection rates (Cont'd)

Author, year, country,	Study design MMAT quality score	Description of intervention (study objective, target population, screening test, MSU type, time period of study)	Sample (number of clients screened or exams, demographics)	Reported cancer screening performance indicators	Cancer detection rate/1,000 exams
Frelix et al. (1999), USA (35)	Quantitative descriptive MMAT: 75%	Target: women ≥40 in The Bronx borough of New York city (underserved population) Test: film MMG + CBE; MSU type: 2 vans Period: 1994–95 (16 mos.); opportunistic screen	1,944 clients screened; 45.6% uninsured	Abnormal call rate: 18.5% ($n = 360$); biopsy rate: 2.5% ($n = 49$) Compliance rate among biopsy recommendations: 100% Detected cases: $n = 26$; test PPV: 6.9%[a]; biopsy PPV: 51% Proportion DCIS: 16% ($n = 4$); stage I: 36% ($n = 9$)	13.3[a]
Kann et al. (1998), USA (82)	Quantitative descriptive MMAT: 75%	Target: Women ≥40 in Long Island, New York Test: film MMG and CBE; MSU type: 1 van Period: 1990–1994 (5 years); organized program	19,280 exams	Biopsy recommendation rate: 1.5% ($n = 295$); biopsies performed: 0.8% ($n = 157$); Loss to follow-up: 46.8% ($n = 138$) Detected cases: $n = 64$; PPV recommended & performed biopsies: 21.6% & 40.8%[a] Operational measures: 30 tests offered per day	3.3[a]
Horton et al. (1996), UK (66)	Prospective cohort MMAT: 50%	Target: women ages 65–74 in Hamstead, UK, not routinely invited to breast cancer screening through the National Health Service (NHS) Test: film MMG; MSU type: 1 van Comparison: women ages 50–64 invited for screening by the NHS Period: 1992–1993 (0.5 year); organized program	4,576 clients screened	Results for age groups: 50–64, 65–69, 70–74 respectively Abnormal call rate: 3.2% ($n = 92$), 4.1% ($n = 32$), 4.8% ($n = 44$) Biopsy rate: 0.5% ($n = 14$), 1.6% ($n = 12$), 1.5% ($n = 14$) Detected cases: $n = 13$, $n = 11$, $n = 12$ Test PPV: 14.1%, 34.4%, 27.3%[a] Biopsy PPV: 92.9%, 91.7%, 85.7%[a]	4.5 (50–64 years; 14.2 (65–69 years); 13.2 (70–74 years)
Séguret et al. (1995), France (72)	Quantitative descriptive MMAT: 100%	Target: 52,617 women ages 40–70 in Herault region, France Test: film MMG; MSU type: 1 van Period: 1990–1992 (2.5 years); organized program	26,026 clients screened	Screening coverage rate = 48% Abnormal call rate: 7% ($n = 1,826$); loss to follow up among recalls = 10.6%; Biopsy rate: 1.5% ($n = 393$) Detected cases: $n = 137$; reported PPV (8.4%) based on clients who returned for follow-up; Test PPV: 7.5%[a]; Biopsy PPV: 35%; Proportion cases *in situ*: 18% ($n = 27$); tumors <1 cm: 42%; Detected interval cancers within 30 mos.: $n = 13$	5.3
Van Oyen et al. (1994), Belgium (74)	Quantitative descriptive MMAT: 75%	Target: 57,339 women ages 50–64 in Antwerp and Limburg provinces Test: MMG not otherwise specified MSU type: 1 semi-mobile unit (mammography machine, transported in an adapted trailer and set up in a central clinic in each visited town) Period: 1989–1992 (4 years); organized program	16,017 clients screened	Screening coverage rate = 28%; Abnormal call rate: 4.1% ($n = 652$); Loss to follow up among abnormal calls: 15% Biopsy rate: 0.6% ($n = 89$) Detected cases: $n = 46$; Test PPV: 8.3% (reported); Test PPV: 0.071[a]; Biopsy PPV: 51.7% Proportion DCIS: 30%; stage 1 (<2 cm): 59.5% Median time from screening to diagnosis: 4 weeks Operational measures: 45 exams offered daily	2.9

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Table 3. Descriptive summary of quality, performance indicators, and case detection rates (Cont'd)

Author, year, country,	Study design MMAT quality score	Description of intervention (study objective, target population, screening test, MSU type, time period of study)	Sample (number of clients screened or exams, demographics)	Reported cancer screening performance indicators	Cancer detection rate/1,000 exams
Garas et al. (1994), Greece (73)	Quantitative descriptive MMAT: 100%	Target: 42, 411 women ages 40–64 in the Ilia and Messinia counties, southern Greece Test: film MMG; MSU type: 1 van (multimodal, also provided Pap tests, results unreported) Period: 4 years; organized program	22,258 clients screened	Screening coverage rate = 52.5%; Abnormal call rate: 5.3% (n = 1169); biopsy rate: 0.8% (n = 176) (recommended), 0.7% (n = 158) performed, loss to follow-up: 11% Detected cases: n = 69; test PPV: 7.4%; biopsy PPV: 47.1% Proportion DCIS: 4.3%; stage 1 (< 2cm): 51.5%	3.1
Dershaw et al. (1992), USA (55)	Quantitative descriptive MMAT: 75%	Target: women age ≥35 in New York state Test: film MMG (Pap tests also offered, results not reported by study) MSU type: 1 van, 2 semi-mobile MMG units Period: 1988–1991 (3 years); opportunistic screen	22,540 exams	Abnormal call rate: 11.2% (n = 2515); biopsy recommended rate: 0.6% (n = 288); biopsy performed rate Detected cases: n = 50; test PPV: 2.0%; biopsy PPV (recommended): 17.3%; biopsy PPV (performed): 21% Operational measures: 25 exams offered daily. Costs (USD 1992): average cost per test = $65; startup costs $360,000;	2.2
McCoy et al. (1992), USA (36)	Quantitative descriptive MMAT: 50%	Target: women age ≥40 in Florida (socioeconomically disadvantaged) Test: film MMG (Pap tests also offered, results not reported by study); MSU type: 1 van Period: 1987–1991 (4 years); opportunistic screen	12,456 clients screened; First-screen: 72%	Abnormal call rate: 21.3% (n = 2,660) Detected cases: n = 90, test PPV: 4.0%[a] Proportion of cases DCIS: 10% (years 1987–89), 24% (years 1990–91)	6.6 (prevalent rate) 5.5 (overall rate)[a]
Tabar and Gad (1981), Sweden (22)	RCT MMAT: 100%	Target: 47,000 women age ≥40 Ostergotland county, Sweden; MSU type: 1 van Test: film MMG; control: no screening (22,000 women in Kopparberg county) Period: 1977–1980 (3 years); organized program	34,187 clients screened	Screening coverage rate among intervention group: 84.3% Abnormal call rate: 4.8% (n = 1655); biopsy rate: 0.1% (n = 362) Detected cases: n = 235; Test PPV: 14.2%[a]; biopsy PPV: 64.9%[a]	6.9[a]
Strax (1973), USA (23)	RCT MMAT: 50%	Target: 31,000 women age 40–64 participating in the Health Insurance Plan (HIP) in New York City Test: film MMG and CBE; MSU type: 1 van control group: no screening (31,000 women randomly matched on age, through HIP program) Period: 1963–1969 (7 years); organized program	20,211 clients screened	Intervention group: screening coverage rate: 66% Detected cases: n = 296; detection rate per 1,000 PYs: 2.72 70% of cases were without axillary nodal involvement Comparison group: Detected cases: n = 284; detection rate per 1,000 PYs: 1.86 45% of cases were without axillary nodal involvement	2.3

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Table 3. Descriptive summary of quality, performance indicators, and case detection rates (Cont'd)

	Author, year, country,	Study design MMAT quality score	Description of intervention (study objective, target population, screening test, MSU type, time period of study)	Sample (number of clients screened or exams, demographics)	Reported cancer screening performance indicators	Cancer detection rate/1,000 exams
Cervical Cancer	Lorenzi et al. (2016), Brazil (21)	Quantitative descriptive MMAT: 75%	Objective: To evaluate the efficiency of the careHPV test in detecting high-risk HPV in women with no precursor lesions and evaluate performance as a primary screening method Target: women ages 18–85 residing in 4 states of South-East and Central-West Brazil Cotesting: CareHPV + Pap-liquid based cytology (Pap-LBC) MSU type: 1 van Period: 03–12/2012 (8 mos.); opportunistic screen	3,068 clients screened; Median age (range) = 47 (18–85)	Test positive for HR-HPV: 10.0% ($n = 307$) Abnormal cytology: total 4.3% ($n = 132$): [ASC/AGC-US: $n = 66$, ASC/AGC-H: $n = 13$, LSIL: $n = 38$, HSIL: $n = 15$]; HR-HPV positivity among cytology samples: 8.2% of normal samples, 39.4% of ASC/AGC-US, 38.5% of ASC/AGC-H, 55.3% of LSIL, 100% of HSIL Colposcopy rate: 10.8% referred ($n = 332$); 3.6% performed ($n = 111$); 66% loss to follow-up Biopsy rate: 2.1% ($n = 66$), CIN1: 40.9% ($n = 27$); CIN2: 7.6% ($n = 5$); CIN3: 6.1% ($n = 4$); invasive carcinoma: 4.5% ($n = 3$) HPV test: Sensitivity: 100% (CI: 75.3–100%), specificity: 10.8% (CI: 5.1–19.6%)	1 invasive cancer/1,000 women cotested
	Paengchit et al. (2014), Thailand (25)	Quantitative descriptive study MMAT: 100%	Objective: describe prevalence and genotype distribution of HPV in Lampang, Thailand Target: women ages 30–70 Test: Pap-LBC, HR-HPV testing; MSU type: 1 van Period: 01–03/2013 (3 mos.); opportunistic screen	2,000 clients screened; Mean age (range) = 47.8 (30–70)	Test positive for HR-HPV: 5.4% (CI: 4.5–6.5; $n = 108$) Rate of abnormal cytology: 1.95% (1.4–2.7) Number with HSIL or higher: $n = 19$ HR-HPV positivity among cytology samples: 4.0%, 60.0%, 89.5% among normal, ASC-US/LSIL, HSIL respectively	9.5 HSIL/1,000 smears[a]
	Fregnani et al. (2013), Brazil (27)	Cross-sectional analytic MMAT: 100%	Test: Pap, comparison: Pap LBC MSU type: 1 van Period: 05–12/2010 (8 mos.); opportunistic screen	Pap, Pap-LBC Clients screened: 6,047, 6,001 Mean age (SD): 46.1 (13.1), 46.5 (12.5)	Results for Pap, Pap-LBC: Abnormal call rate: 0.021, 0.01; Specimen adequacy rate: 99.92%, 99.97% ASCUS-US: 0.1% ($n = 6$), 0.7% ($n = 39$); ASC-H: 0.3% ($n = 21$), 0.4% ($n = 24$); LSIL: 0.3% ($n = 19$) vs 0.7% ($n = 41$); HSIL: 0.2% ($n = 14$) vs 0.4% ($n = 22$)	Rate of HSIL per 1,000 smears: 2 vs. 4
	Swaddiwud-hipong et al (1999), Thailand (20)	Mixed: qualitative case-study + quantitative descriptive MMAT: 100%	Objective: measure effect of MSU program on knowledge and attitudes toward screening Target: low-income women residing in rural regions of Thailand, ages 18–65 Test: Pap; MSU type: 1 van; Period: 1992–1996 (5 years); Opportunistic screen	13,081 clients screened; Women surveyed in 1991, 1994, 1997: $n = 1,603$, $n = 1,369$, $n = 1,576$	LSIL: $n = 46$ (0.4%); HSIL (%): $n = 46$ (0.4%); detected cases: $n = 7$ Survey results from 1991, 1994, 1997 Self-reported knowledge of Pap test: 21%, 57%, 76% Self-reported use of Pap test: 20%, 58%, 70%	0.5 cases/1,000 smears 3.5 HSIL/1,000 smears
	Megevand et al. (1996), South Africa (15)	Prospective cohort MMAT: 100%	Objective: to identify operational strategies to minimize loss to follow-up Target: low-income women in Capetown Test: (phase I) Pap + Colposcopy referral to FC; (phase II "See, screen, treat"): Pap + Colposcopy in MSU; MSU type: 1 van; Period: 1993 (8 mos.); opportunistic screen	Phase I, II: clients screened; 2,619, 2,426 Mean age (range): 34 (19–83), 31 (17–78); Total First-screen: 75.2%	Results for Phase 1, 2: Abnormal Pap smears - LSIL: 3.3% ($n = 87$), 3.5% ($n = 87$); HSIL: 3.2% ($n = 86$), 1.3% ($n = 33$) Effective completion of colposcopy among HSIL: 33% (29/86), 97% (32/33) Operational measures: 50 tests offered per day	0.92/1,000 smears[a]

(Continued on the following page)

Table 3. Descriptive summary of quality, performance indicators, and case detection rates (Cont'd)

	Author, year, country,	Study design MMAT quality score	Description of intervention (study objective, target population, screening test, MSU type, time period of study)	Sample (number of clients screened or exams, demographics)	Reported cancer screening performance indicators	Cancer detection rate/1,000 exams
	Thornton et al. (1989), UK (54)	Quantitative descriptive MMAT: 100%	Target: Women >40 employed by worksites in West Surrey/North-East Hampshire region (UK) Test: Pap, CBE (unreported); MSU type: 1 van Period: 1985–1986 (9 mos.); opportunistic screen	568 clients screened	Coverage rate among women in targeted workplaces: 91% Abnormal call rate: $n = 64$ (0.11); Detected cases: 1; Test PPV: 1.5%[a]	1.76 cases/ 1,000 smears
	Brindle et al. (1976), UK (49)	Quantitative descriptive MMAT: 100%	Target: women (age unspecified) residing in the UK; Test: Pap; MSU type: 1 van Period: 1973 (3 mos.); opportunistic screen	1,526 clients screened; First-screen: 70%	Abnormal call rate: $n = 10$ (0.66%)	6.6 abnormal/ 1,000 smears
	Whitfield et al (1972), UK (50)	Quantitative descriptive MMAT: N/A	Target: women (16–60) residing in the UK Test: Pap (CBE also offered, results unreported); MSU type: 1 van Period: 1969–71 (3 years); opportunistic screen	1,952 clients screened; first-screen: 70%	Number of cases carcinoma *in situ*: $n = 4$ Cost measurements (reported in 1972 pounds (£)): Cost per test = £2, average cost per detected CIN3 = £200	2.04 cases of carcinoma *in situ*/1,000 smears
Breast, cervical	Mauad et al. (2009), Brazil (70)	Quantitative descriptive MMAT: 100%	Target: 54,238 women ages 40–69 for breast screening, 117,239 women ages 20–69 for cervical screening Test: Film MMG and Pap MSU type: 1 van Period: 2003–2004 (2 years); opportunistic screen	MMG, Pap: clients screened: 7,192, 2,964; First-screen: 44%, 7%	Breast: screening coverage rate: 13%; Abnormal call rate: 7.6% ($n = 549$); biopsy rate: 1.4% ($n = 105$); Detected cases: $n = 22$; test PPV: 4%[a]; biopsy PPV: 20.9%[a] Cervical: screening coverage rate: 2.5% Abnormal call rate: 1.9% ($n = 59$)[a]; cytologic abnormalities: 0.5% ($n = 15$): ASCUS 0.1% ($n = 3$); CIN1 0.13% ($n = 4$); CIN2 0.1% ($n = 3$); CIN3 0.1% ($n = 3$); invasive squamous cell carcinoma 0.07% ($n = 2$); operational measures: 40 exams offered daily	Breast: 3.1 cases/1,000 exams Cervical: 0.7 cases/1,000 exams
Breast, cervical, prostate, gastric, oral, colon and lung	Lynch (1976), USA (94)	Quantitative descriptive MMAT: 50%	Objective: Measure effectiveness of MSU by comparing survival with general U.S. population Target: Adults residing in rural Nebraska; Test: *unspecified;* MSU type: custom-built house, 6 m × 18 m in dimension (transported using tractor) Period: 1971–1975 (5 years); opportunistic screen	5,232 clients screened (1,984 men and 3,248 women); Mean age (range) = 55 (18–90)	Detected cases: $N = 22$ (8 breast, 7 colon, 2 endometrium, 1 lung, 1 prostate, 1 penis, 1 lip, 1 stomach) 1 cancer diagnosis per 238 clients screened Survival: observed vs. expected deaths: 3 vs. 7.5 (estimated using U.S. cancer mortality rates)	4.2 cases/1,000 people screened
Breast, cervical, prostate, gastric, oral, colon skin, penile	Lynch, (1973), USA (67)	Quantitative descriptive MMAT: 25%	Target: individuals residing in eight communities in Nebraska; Test: MMG (NOS), CBE, Pap, DVI, proctosigmoidoscopy, OVE, laryngoscopy MSU type: custom-built house (transported by tractor) Period: 1971–1972 (2 years); opportunistic screen	3,040 screening exams; Mean age = 60 (males), 56 (females)	Total number of malignancies: $n = 13$ ($n = 64$ including skin) Operational measures: 16 patients scheduled per hour	4.3 cases/1,000 people screened

Abbreviations: CBE, clinical breast exam; CI, 95% confidence interval; DRE, digital rectal exam; DVI, direct visual inspection; FC, fixed-centre; Pap, Papanicolau smear with conventional cytology; Pap-LBC, Papanicolau smear with liquid-based cytology; NOS, not otherwise specified; OVE, oral visual examination; VILI, visual inspection with Lugol iodine.

[a]Denotes hand calculations. The objective is left unspecified for studies which are purely descriptive. If a distinct objective outside of program description was mentioned, this objective was stated. See Supplementary Table S3 for reference to the MMAT scale.

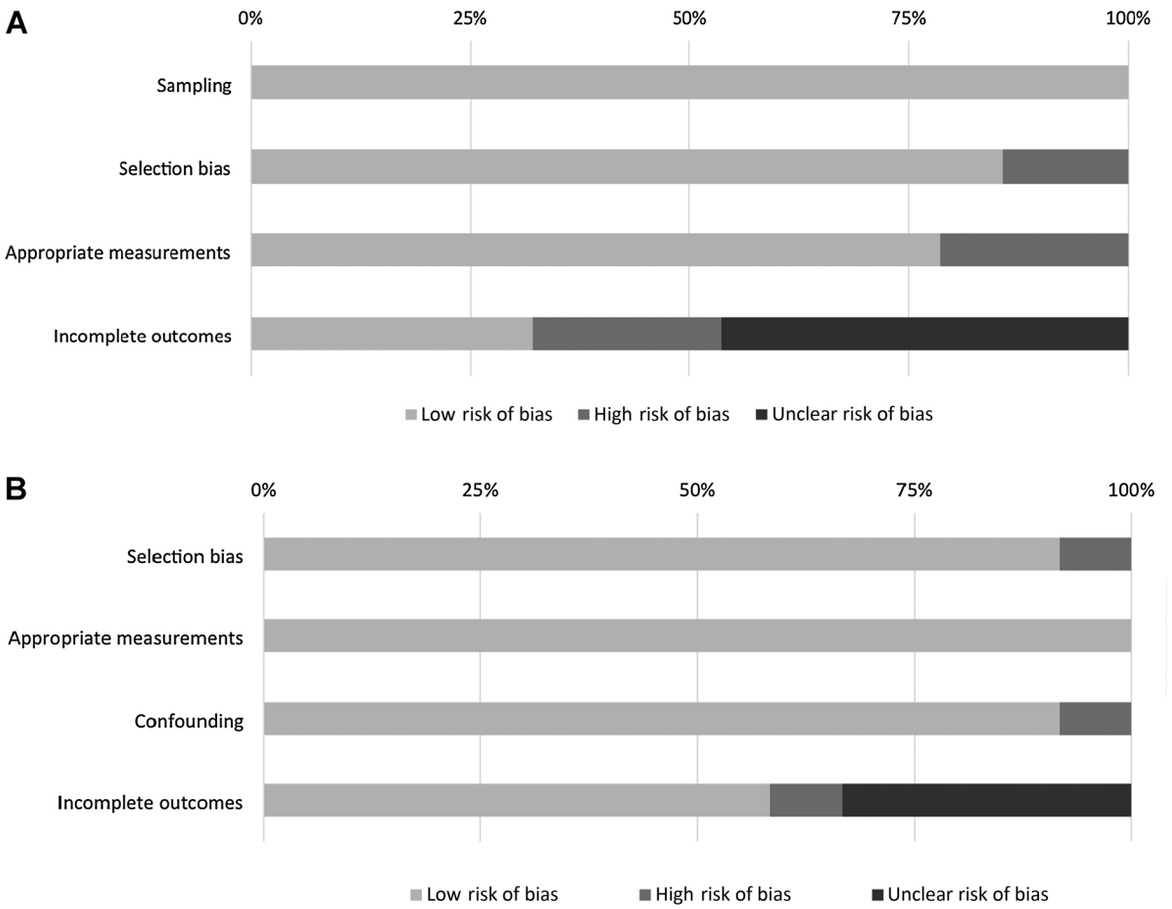

Figure 2.

Assessment of risk of bias by study design. Review authors' judgments about each methodologic criterion are presented as percentages across the 22 studies of quantitative descriptive design (**A**) and 7 studies of nonrandomized observational design (**B**). Judgments were based on criteria outlined in the MMAT (Supplementary Table S3).

contexts. As displayed in Fig. 3, among 22 breast cancer screening studies reporting performance measures, case detection rates ranged from 2.15 to 14.65 per 1,000 mammography exams. In these studies, patients with abnormal screening results were recalled to fixed clinics for further clinical work-up and diagnostic exams. The broad range in detection rates may be due to differences in contextual factors between programs such as the ages of screened women, proportion of never-screened women, or differences in incidence rates of breast cancer in various settings.

Twelve studies described cervical cancer MSU programs involving screening exams performed by nurse technicians including: conventional or liquid-based Pap cytology, HPV testing, and visual inspection with acetic acid (VIA); one MSU also offered diagnostic colposcopy exam performed by a clinician (15). All 10 multiphasic programs reported screening for cervical cancer. Notably, many of the cervical cancer screening studies were in low-resource settings in Brazil, Peru, South Africa, India, Thailand, and Taiwan (15, 20, 21, 24–27). The studies report diverse outcomes of detection of precancerous cervical lesions and invasive cancer, as described in Table 3. Because of the inconsistency of reporting measures used, no summary figure of case detection is presented for the cervical cancer screening studies.

Mechanisms for increasing delivery, access, and demand for screening

Examples of operations of MSUs in regions distant from centralized services include cervical cancer screening in tents in the Andes Mountains of Peru (26); a mammography unit transported by boat and plane to reach Arctic regions in Canada (14); an MSU mammography program serving residents of 26 inhabited islands in Scotland (28); a semi-mobile colonoscopy program for high-risk individuals in South Africa residing over 500 km away from the nearest hospital (29); and MSU interventions for breast and cervical cancer in the rural interior and Amazonian states of Brazil (21, 30). In addition, MSUs fill a unique niche in urban areas by targeting underscreened groups who may be within a reasonable physical proximity to a fixed clinic, but less likely to access services due costs, awareness, and perceived barriers (26, 31–37).

Key factors to the accessibility of services are the time and distance traveled to a screening center. Some studies reported patients' travel to the MSU location to be fairly minimal, with average distances traveled by clients to reach MSU sites of 4.5–34 km (38–40). One study from the United Kingdom found MSUs were located substantially closer to patients than

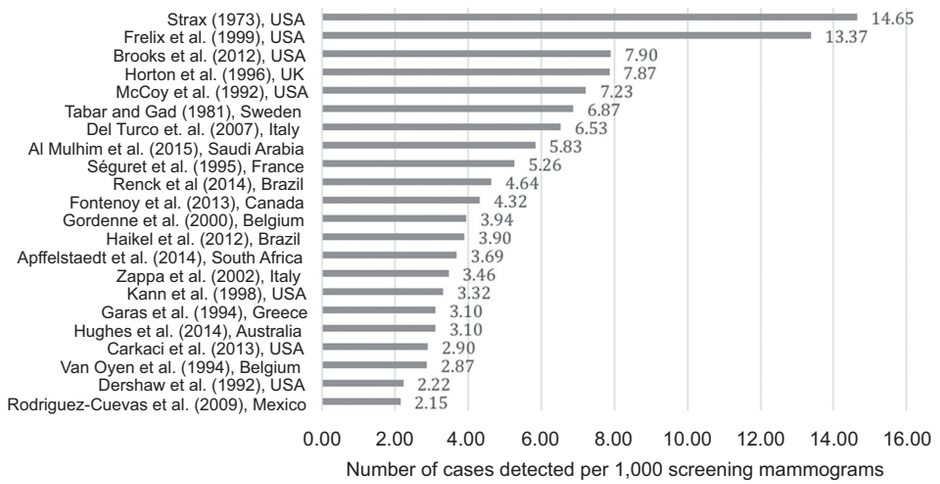

Figure 3.
Breast cancer case detection rates per study among the subset of breast cancer studies reporting performance indicators ($n = 22$). Crude case detection rates corresponding to the number of detected cases of cancer per 1,000 mammography exams are presented.

fixed clinics; the mean distance per client to an MSU was 6.4 km as compared with fixed clinics that were on average 18.2 km away (41).

Community access to screening

Several MSU programs aimed to increase community access to screening (24, 34, 42–48). An increased screening rate from 44.3% to 63.4% was reported in regions served exclusively by MSUs in Quebec, Canada over a course of eight years (14). A Thai study found an increase in the proportion of women reporting ever receiving a Pap smear from 20% in 1991, to 70% in 1999 due to MSU operations (20).

In cases where before and after measures of screening uptake were unavailable, using the proportion of never-screened individuals who received their first screening exam through the program can serve as a surrogate measure for increased access. Among breast screening programs, studies reported the proportion of first-screen clients to range from 11% to 72% (18, 30, 36). Cervical cancer screening programs targeting low-income groups reached particularly underserved populations composed of 75% never-screened clients in South Africa (15), and 70% never-screened clients in the United Kingdom (49, 50).

MSU programs have addressed economic barriers to screening by reaching underserved populations. Notably, 31% ($n = 24$) of studies offered screening services free of charge. The majority of studies that discussed fee-for-service economic barriers to screening were based in the United States where no organized breast cancer screening program existed and attending screening was likely to be affected by insurance status (17, 34, 35, 42–44, 47, 48, 51–53). Furthermore, a number of MSU programs have decreased structural barriers by offering screening at the workplace (49, 54–58), shopping centers (50), and retirement homes (59).

Client demand

Client demand for screening is an essential part of attaining population-level screening coverage. MSU qualitative studies used focus groups and surveys to identify women's attitudes towards screening, their perception of the utility of screening and intent to screen (28, 38, 39, 46, 60–64). Among women surveyed following MSU screening, nonadherence to screening guidelines was reported as related to a lack of awareness of early detection, lack of accessible information, negative beliefs or attitudes toward screening, as well as fear of discomfort/embarrassment, cost, and bad news (34, 61, 63).

Studies reported high levels of overall client satisfaction with the quality of service (24, 62, 64) and adequate levels of comfort and privacy with screening (24, 62, 65). Two studies measured patient preferences and documented preference for MSU relative to fixed-site clinic (24, 62). In contrast, one study reported a lower client satisfaction for MSUs relative to hospital screening in terms of receipt of test results, staff interpersonal skills, privacy, physical surroundings, and general satisfaction (64).

Studies described various methods to promote screening attendance, including direct invitation by mail or telephone, publicity (flyers, radio, car loudspeaker, newspaper), word of mouth, or physician referral (32, 38, 49, 62, 66–69). A study conducted during the initial implementation of a breast and cervical cancer screening program in Brazil found that among various promotion strategies, community health care agents making home visits was the most effective means of recruiting women to begin screening (70).

Determinants of successful follow-up

Compliance to the recommended follow-up of an abnormal screening exam serves as an indicator of the quality of a screening program. Rates of loss to follow-up generally tended to be higher in low and middle-income countries. A 21% loss to follow-up rate of the MSU mammography screening program in Mexico City (71) and a 66% loss to follow-up for colposcopy referrals in the MSU cervical cancer screening program in Brazil (21) were found compared with a 10%–15% loss to follow-up in the MSU breast screening programs in France (72), Greece (73), and Belgium (74). MSU operations should strive to minimize potential delays in the referral pathway and loss to follow-up that may occur due to a delay between the screening test and dissemination of results/availability of treatment. A cervical cancer screening study in South Africa assessed the effect of a "see, screen, treat" intervention to minimize loss to follow-up and found improved rates of completed follow-up when clients with suspected lesions were referred to the MSU for diagnostic colposcopy and lesion excision (15). Ninety-eight percent of patients with high-grade squamous intraepithelial lesions (HSIL) attended MSU colposcopy as compared with 33% complete follow-up when referred for colposcopy at the nearest hospital, which was 30 km away from the MSU site.

Discussion

This review summarizes the evidence regarding the feasibility of MSU interventions for the early detection of cancer. We described existing programs, their performance, and the mechanisms through which they can increase the delivery, access, and demand for screening services. It was evidenced that MSUs can increase access for underscreened groups. Offering early detection services through MSUs is a practical way for service providers to increase physical and economic access to screening while reducing barriers for clients (structural barriers and out-of-pocket costs).

However, there are several challenges and risks involved with offering screening via MSUs as compared with fixed clinics. Referral systems and challenges with follow-up are a major issue. In an MSU setting, the exam is generally conducted by a nurse technician on the MSU and any abnormalities that are found upon interpreting the exam, will require the patient to travel to a fixed clinic to visit a physician on a separate date, whereas a fixed clinic may have the flexibility to conduct a diagnostic exam on the same day and minimize potential losses to follow-up. In addition, MSUs face unique risks when compared with fixed clinics—poor roads may necessitate the recalibration of sensitive diagnostic machinery if transported by MSU. Finally, client perceptions of MSUs may differ from fixed-clinics, as MSUs are generally perceived as less clinical than hospital-based clinics. This review did not focus on the clinical considerations of screening tests with respect to their effectiveness in reducing morbidity or mortality for cancer sites. However this serves as an area for future study to determine whether MSUs are as clinically effective as fixed facilities.

The body of evidence summarized by these studies is modest. The study designs were largely descriptive single-group studies, with few high-quality observational studies and RCTs documenting the performance of MSUs, the latter type representing the highest level of evidence, followed by observational studies and descriptive studies (75). Among studies that were appraised for methodologic quality, we found a low risk of bias for measures including sampling, selection bias, and valid measurements. However, several studies were methodologically weak and at high risk of bias for the incomplete reporting of outcome measures. Therefore, although the overall methodologic quality of the studies summarized by our review was at a moderately low risk of bias, the strength of evidence continues to be limited. A weakness of this quality review is that some studies scored decently on the MMAT scale, despite shortcomings in design and reporting. We found the MMAT scale was restrictive with respect to scoring the methodologic quality of screening studies. The design and methods employed by future studies of MSUs should pay particular attention to reporting of complete outcomes.

There are potential risks associated with screening in general, particularly if the test and the medical procedures that are required in consequence are inefficiently administered. This includes the potential for missing cancers (false negatives) and patients undergoing unnecessary clinical follow-up if they test positive but do not have the disease (false positives). Regrettably, risks of screening may be worsened in settings where follow-up is limited, because individuals with abnormal tests may not return and the period between screening rounds may extend beyond the recommended intervals, thus permitting development of interval cancers. Few studies reported the potential for false negative test results which can be measured as the number of interval cancers occurring within 24 months of a negative test result or by reporting test specificity (13, 21, 72, 76). Using a descriptive single-group study design measuring rates of cancer detection at baseline (cross-sectional), and without follow-up data, it is not possible to assess the rates of false-negative results. With respect to prevalence of false positives, due to the wide ranges of reported positive predictive values of tests and the lack of reporting on confounding characteristics in the study population (most notably age) it was not possible to summarize rates of false positives across studies.

The findings of individual studies have limited generalizability. The quantitative findings in terms of test performance cannot be directly compared between studies or generalized to other settings due to differences in baseline risk of cancer and the non-reporting of age-standardized detection rates. The qualitative outcomes such as the acceptability of a given cancer screening test and client satisfaction levels with MSU services are also highly contextual, and cannot be generalized across studies.

Insufficient evidence was available to describe the cost-effectiveness of MSU interventions but we hypothesize that MSUs have lower start-up costs compared with fixed sites but may face greater maintenance costs for technology and equipment due to stress caused by road travel. Conducting studies to investigate the cost-effectiveness of MSU programs relative to fixed clinics should be a priority.

The MSU studies included in this review were not restricted by study design, types of screening tests used, or types of outcomes reported. This broad inclusion criterion is both a strength and a limitation of this review. Studying multiple MSU interventions emphasized the versatility of MSU programs but limits the depth of analysis for performance outcomes of individual programs. The literature search was limited to programs that explicitly described the methods of screening as mobile or used a synonym listed within the search (Supplementary Table S1). The search was designed to be as robust and detailed as possible. However, it is possible that some studies were overlooked. Publication bias may have led to nonpublication of MSU studies of high and poor quality that do not report their findings in peer-reviewed journals. This review was only able to synthesize published results.

This review synthesizes the available knowledge regarding MSU interventions for cancer screening. MSUs can be an important health system component to expand screening coverage to rural areas or to urban residents who fail to be reached by health promotion messages or lack medical insurance. Overall, our findings highlight the value of MSU interventions, specifically with respect to increasing access to early detection services. More evidence is needed to provide comparative information on the cost-effectiveness and effectiveness of MSU interventions as compared with fixed-clinics to inform decision making for health care providers or policymakers.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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References

1. Gelband H, Jha P, Sankaranarayanan R, Horton S. Cancer. Washington, DC: World Bank; 2015.
2. World Health Organization. Cancer control knowledge into action. WHO guide for effective programmes. Early Detection. Geneva. Switzerland: World Health Organization; 2007.
3. Baron RC, Rimer BK, Coates RJ, Kerner J, Kalra GP, Melillo S, et al. Client-directed interventions to increase community access to breast, cervical, and colorectal cancer screening a systematic review. Am J Prev Med 2008;35: S56–66.
4. Brown ML, Fintor L. U.S. screening mammography services with mobile units: results from the national survey of mammography facilities. Radiology 1995;195:529–32.
5. Sabatino SA, Lawrence B, Elder R, Mercer SL, Wilson KM, DeVinney B, et al. Effectiveness of interventions to increase screening for breast, cervical, and colorectal cancers: nine updated systematic reviews for the guide to community preventive services. Am J Prev Med 2012;43: 97–118.
6. Vellozzi CJ, Romans M, Rothenberg RB. Delivering breast and cervical cancer screening services to underserved women: literature review and telephone survey. Womens Health Issues 1996;6:65–73.
7. Forrest P. Breast cancer screening: report to the Health Ministers of England, Richmond, United Kingdom. HMSO; 1986.
8. Luthra UK, Rengachari R. Organization of screening programs in developing countries with reference to screening for cancer of the uterine cervix in India. IARC Sci Publ 1986:273–88.
9. MyHealthCafe.com. Mobile mammography vans can bring free and low-cost mammograms to you. Available from:http://myhealthcafe.com/mobile-mammography-vans-can-bring-free-and-low-cost-mammograms-to-you.; 2016.
10. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009;6:e1000097.
11. Pluye P, Robert E, Cargo M, Bartlett G, O'Cathain A, Griffiths F, Boardman F, Gagnon MC, Rousseau MC, et al. Proposal: A mixed methods appraisal tool for systematic mixed studies reviews. 2011. Retrieved on 2016-05-021 from http://mixedmethodsappraisaltoolpublic.pbworks.com. Archived by WebCite® at http://www.webcitation.org/5tTRTc9yJ
12. Pace R, Pluye P, Bartlett G, Macaulay AC, Salsberg J, Jagosh J, et al. Testing the reliability and efficiency of the pilot Mixed Methods Appraisal Tool (MMAT) for systematic mixed studies review. Int J Nursing Studies 2012;49:47–53.
13. Hughes JP, Jose DC, Tuch GH, Fritschi L, Tresham J, Wylie E. Is Step Down Assessment of screen-detected lesions as safe as workup at a Metropolitan Assessment Centre? Aust N Z J Public Health 2014;38:44–8.
14. Fontenoy AM, Langlois A, Chang SL, Daigle JM, Pelletier E, Guertin MH, et al. Contribution and performance of mobile units in an organized mammography screening program. Can J Public Health 2013;104: E193–E9.
15. Megevand E, Van Wyk W, Knight B, Bloch B. Can cervical cancer be prevented by a see, screen, and treat program? A pilot study. Am J Obstet Gynecol 1996;174:923–8.
16. Renck DV, Barros F, Domingues MR, Gonzalez MC, Sclowitz ML, Caputo EL, et al. Equity in access to breast cancer screening in a mobile mammography program in southern Rio Grande do Sul state, Brazil; [Portuguese] "Equidade no acesso ao rastreamento mamografco do cancer de mama com intervencao de mamografo movel no sul do rio grande do Sul, Brasil". Cadernos de Saude Publica 2014;30:88–96.
17. Carkaci S, Geiser WR, Adrada BE, Marquez C, Whitman GJ. How to establish a cost-effective mobile mammography program. Am J Roentgenol 2013;201:W691–W7.
18. Del Turco MR, Mantellini P, Ciatto S, Bonardi R, Martinelli F, Lazzari B, et al. Full-field digital versus screen-film mammography: comparative accuracy in concurrent screening cohorts. Am J Roentgenol 2007; 189:860–6.
19. Fregnani JH, Scapulatempo C, Raikel R Jr, Mauad EC, Campacci N, Longatto-Filho A. Liquid-based cytology and the detection of cervical intraepithelial lesions in low and high-risk women for HPV-related diseases. Int J Gynecol Cancer 2012; E606.
20. Swaddiwudhipong W, Chaovakiratipong C, Nguntra P, Mahasakpan P, Tatip Y, Boonmak C. A mobile unit: an effective service for cervical cancer screening among rural Thai women. Int J Epidemiol 1999;28:35–9.
21. Lorenzi AT, Fregnani JH, Possati-Resende JC, Antoniazzi M, Scapulatempo-Neto C, Syrjanen S, et al. Can the careHPV test performed in mobile units replace cytology for screening in rural and remote areas? Cancer Cytopathol 2016;128:581–8.
22. Tabar L, Gad A. Screening for breast cancer: the Swedish trial. Radiology 1981;138:219–22.
23. Strax P. Mass screening for breast cancer. Revue Francaise de Gynecologie et d'Obstetrique 1973;68:457–66.
24. Kumar Y, Mishra G, Gupta S, Shastri S. Cancer screening for women living in urban slums–acceptance and satisfaction. Asian Pacific J Cancer Prev 2011;12:1681–5.
25. Paengchit K, Kietpeerakool C, Lalitwongsa S. Prevalence and genotype distribution of HPV among women attending a cervical cancer screening mobile unit in Lampang, Thailand. Asian Pacific J Cancer Prev 2014; 15:6151–4.
26. Ferris DG, Shapiro J, Fowler C, Cutler C, Waller J, Guevara Condorhuaman WS. The impact of accessible cervical cancer screening in Peru-The Dia del Mercado Project. J Lower Genit Tract Dis 2015;19:229–33.
27. Fregnani JH, Scapulatempo C, Haikel RL Jr, Saccheto T, Campacci N, Mauad EC, et al. Could alarmingly high rates of negative diagnoses in remote rural areas be minimized with liquid-based cytology? Preliminary results from the RODEO Study Team. Acta Cytol 2013;57:69–74.
28. Stark CR, Reay L, Shiroyama C. The effect of access factors on breast screening attendance on two Scottish islands. Health Bull 1997; 55:316–21.
29. Bruwer Z, Futter M, Ramesar R. A mobile colonoscopic unit for lynch syndrome: trends in surveillance uptake and patient experiences of screening in a developing country. J Genet Couns 2013;22:125–37.
30. Haikel RL Jr, Mauad EC, Silva TB, Mattos JS, Chala LF, Longatto-Filho A, et al. Mammography-based screening program: preliminary results from a first 2-year round in a Brazilian region using mobile and fixed units. BMC Women's Health 2012;12:32.
31. Apffelstaedt JP, Hattingh R, Baatjes K, Wessels N. Results of a pilot programme of mammographic breast cancer screening in the Western Cape. South African Med J 2014;104:297–8.
32. Falshaw ME, Fenton C, Parsons L, Robson J. Improving the uptake of breast screening: one initiative in East London. Public Health 1996;110:305–6.
33. Roen EL, Roubidoux MA, Joe AI, Russell TR, Soliman AS. Adherence to screening mammography among American Indian women of the Northern Plains. Breast Cancer Res Treat 2013;139:897–905.
34. Fayanju OM, Kraenzle S, Drake BF, Oka M, Goodman MS. Perceived barriers to mammography among underserved women in a Breast Health Center Outreach Program. Am J Surg 2014;208:425–34.
35. Frelix GD, Rosenblatt R, Solomon M, Vikram B. Breast cancer screening in underserved women in the Bronx. J Nat Med Assoc 1999;91:195–200.
36. McCoy CB, Khoury EL, Hermanns LS, Bankston L. Mobile mammography: a model program for medically underserved women. Womens Health Issues 1992;2:196–203.
37. Reuben DB, Bassett LW, Hirsch SH, Jackson CA, Bastani R. A randomized clinical trial to assess the benefit of offering on-site mobile mammography in addition to health education for older women. Am J Roentgenol 2002;179:1509–14.
38. Scammon DL, Smith JA, Beard T. Mammography screening services: market segments and messages. J Ambul Care Mark 1991;4:1–16.
39. Maheswaran R, Pearson T, Jordan H, Black D. Socioeconomic deprivation, travel distance, location of service, and uptake of breast cancer screening in North Derbyshire, UK. J Epidemiol Community Health 2006;60:208–12.
40. Kohli HS, Teo PY, Howie FM, Dobson HM. How accessible is the breast screening assessment centre for Lanarkshire women? Health Bull 1995;53:153–8.
41. Bond A, Jones A, Haynes R, Tam M, Denton E, Ballantyne M, et al. Tackling climate change close to home: mobile breast screening as a model. J Health Serv Res Policy 2009;14:165–7.
42. Brooks SE, Hembree TM, Shelton BJ, Beache SC, Aschbacher G, Schervish PH, et al. Mobile mammography in underserved populations: analysis of outcomes of 3,923 women. J Commun Health 2013;38:900–6.

43. Peek ME, Han J. Mobile mammography: Assessment of self-referral in reaching medically underserved women. J Nat Med Assoc 2007;99:398–403.
44. Vyas A, Madhavan S, Kelly K, Metzger A, Schreiman J, Remick S. Do Appalachian women attending a mobile mammography program differ from those visiting a stationary mammography facility? J Commun Health 2013;38:698–706.
45. Copeland VA. Factors that influence follow-up after an abnormal mammogram. College Station, TX: Texas A & M University; 2010.
46. Orton M, Fitzpatrick R, Fuller A, Mant D, Mlynek C, Thorogood M. Factors affecting women's response to an invitation to attend for a second breast cancer screening examination. Br J Gen Pract 1991;41:320–2.
47. Vyas A, Madhavan S, LeMasters T, Atkins E, Gainor S, Kennedy S, et al. Factors influencing adherence to mammography screening guidelines in Appalachian women participating in a mobile mammography program. J Commun Health 2012;37:632–46.
48. Moore CE, Durden F. Head and neck cancer screening in homeless communities: HEAL (Health Education, Assessment, and Leadership). J Nat Med Assoc 2010;102:811–6.
49. Brindle G, Higham E, Roberts DJ, Wakefield J, Yule R. Response to a mobile cervical screening unit in an industrial area of England. Public Health 1976;90:165–9.
50. Whitfield AP. Cervical cancer screening programmes and voluntary support. Royal Soc Health J 1972;92:282–7.
51. Lane A, Martin M, Uhler J, Workman L. Enhancing breast health in rural populations: clinical nurse specialist as the key. Clin Nurse Specialist 2003; 17:292–7.
52. Kluhsman BC. Where science and communities meet: A comparative case study of strategies to increase cancer screening among rural residents [dissertation]. Denver (CO): University of Colorado Denver; 2009.
53. Mizuguchi S, Barkley L, Rai S, Pan J, Roland L, Crawford S, et al. Mobile mammography, race, and insurance: use trends over a decade at a comprehensive urban cancer center. J Oncol Pract 2015;11:e75–80.
54. Thornton J, Chamberlain J. Cervical screening in the workplace. Community Med 1989;11:290–8.
55. Dershaw DD, Liberman L, Lippin BS. Mobile mammographic screening of self-referred women: results of 22,540 screenings. Radiology 1992;184: 415–9.
56. Kessler HB, Rimer BK, Devine PJ, Gatenby RA, Engstrom PF. Corporate-sponsored breast cancer screening at the work site: results of a statewide program. Radiology 1991;179:107–10.
57. Kettlehake J, Malott JC. Mobile screening mammography for the corporate customer. Radiol Manage 1988;10:34–8.
58. Kristjansson S, Helgason AR, Rosdahl I, Holm LE, Ullen H. Readiness to change sun-protective behaviour. Eur J Cancer Prev 2001;10:289–96.
59. Rimer BK, Resch N, King E, Ross E, Lerman C, Boyce A, et al. Multistrategy health education program to increase mammography use among women ages 65 and older. Public Health Rep 1992;107:369–80.
60. Kennedy S, Stephens S, Tephabock K, Brown P, Davis P, Keresztury J, et al. From high tech to high touch: integrating community voices in mobile mammography outreach. W V Med J 2009;105 Spec No:74–7.
61. Logan L, McIlfatrick S. Exploring women's knowledge, experiences and perceptions of cervical cancer screening in an area of social deprivation. Eur J Cancer Care 2011;20:720–7.
62. Hamilton EL, Wallis MG, Barlow J, Cullen L, Wright C. Women's views of a breast screening service. Health Care Women Int 2003;24:40–8.
63. Roberson NL.Breast cancer screening in older black women. Cancer 1994;74:2034–41.
64. Yoon NH, Lee HY, Kwak MS, Choi KS, Jun JK, Kim MK, et al. Comparison of satisfaction with cancer screening at mobile van and static sites: National Cancer Screening Program in Korea. Japanese J Clin Oncol 2009;39:169–74.
65. Sutton S, Saidi G, Bickler G, Hunter J. Does routine screening for breast cancer raise anxiety? Results from a three wave prospective study in England. J Epidemiol Commun Health 1995;49:413–8.
66. Horton Taylor D, McPherson K, Parbhoo S, Perry N. Response of women aged 65–74 to invitation for screening for breast cancer by mammography: A pilot study in London, UK. J Epidemiol Commun Health 1996;50:77–80.
67. Lynch H, Lynch J, Kraft C. A new approach to cancer screening and education. Geriatrics 1973;28:152–7.
68. Haiart DC, Henderson J, McKenzie L, Kirkpatrick AE. A mobile breast screening project in Scotland: lessons learned for national screening. Int J Health Plann Manage 1990;5:201–13.
69. Al Mulhim FA, Syed A, Bagatadah WA, Al Muhanna AF. Breast cancer screening programme: experience from Eastern province, Saudi Arabia. East Mediterr Health J 2015;21:111–9.
70. Mauad EC, Nicolau SM, Moreira LF, Haikel RL, Longatto-Filho A, Baracat EC. Adherence to cervical and breast cancer programs is crucial to improving screening performance. Rural Remote Health 2009;9:1241-.
71. Rodriguez-Cuevas S, Guisa-Hohenstein F, Labastida-Almendaro S. First breast cancer mammography screening program in Mexico: initial results 2005–2006. Breast J 2009;15:623–31.
72. Séguret F, Daures JP, Guizard AV, Mathieu-Daude H, Bonifacj JC, Cherifcheik J, et al. Herault breast screening programme: results after 30 months of a mobile French schedule. Eur J Cancer Prev 1995;4:299–305.
73. Garas I, Pateras H, Triandafilou D, Georgountzos V, Mihas A, Abatzoglou M, et al. Breast cancer screening in southern Greece. Eur J Cancer Prev 1994;3:35–9.
74. Van Oyen H, Verellen W. Breast cancer screening in the Flemish region, Belgium. Eur J Cancer Prev 1994;3:7–12.
75. NCI-PDQ. Screening for cancer PDQ screening/detection—health professionals; 2016. National Cancer Institute.Available from:http://www.cancer.gov/about-cancer/screening/hp-screening-overview-pdq.
76. Zappa M, Falini P, Bonardi R, Ambrogetti D, Giorgi D, Paci E, et al. Monitoring interval cancers in mammographic screening: the Florence District programme experience. Breast 2002;11:301–5.
77. Williams EM, Vessey MP. Randomised trial of two strategies offering women mobile screening for breast cancer. BMJ 1989. p158–9.
78. Gordenne W, Parmentier JC, Delleuze JM. Breast cancer mass screening in the Province of Liege. Results after 8 years. J Belge de Radiologie 2000;83:156–9.
79. Lee YM, Yao HH. Demographic factors influencing consensus opinion on the recall for women screened by mobile mammography unit in Taiwan. Iranian J Radiol 2013;10:116–21.
80. Tinkler C, Pegington K, Baldwin R. Breast screening attendance: Making better use of an appointment system. J Med Screening 2001;8:36–8.
81. Swaddiwudhipong W, Mahasakpan P, Chaovakiratipong C, Nguntra P, Tatip Y, Koonchote S, et al. Screening assessment of persons 40–59 years of age in rural Thailand by a mobile health unit. J Med Assoc Thai 1999;82:131–9.
82. Kann PE, Bradley C, Lane DS. Outcomes of recommendations for breast biopsies in women receiving mammograms from a county health van. Public Health Rep 1998;113:71–4.
83. Schweitzer ME, French MT, Ullmann SG, McCoy CB. Cost-effectiveness of detecting breast cancer in lower socioeconomic status African American and Hispanic women through mobile mammography services. Med Care Res Rev 1998;55:99–115.
84. Williams EM, Vessey MP. Compliance with breast cancer screening achieved by the Aylesbury Vale mobile service (1984–1988). J Public Health Med 1990;12:51–5.
85. Rubin E, Frank MS, Stanley RJ, Bernreuter WK, Han SY. Patient-initiated mobile mammography: analysis of the patients and the problems. South Med J 1990;83:178–84.
86. Nielsen B, Miaskowski C, McCoy C, Rudisch M. The development and implementation of standards of care in a breast cancer screening program. Oncol Nur Forum 1991;18:67–72.
87. Cheng HC, Hsu YH. The quality of cervical smears from outreach screening services in remote areas in eastern Taiwan. Tzu Chi Med J 2014;26:170–4.
88. Riza E, Kyriakogianni-Psaropoulou P, Koumantakis E, Symiakaki H, Garas I, Linos A. Cervical cancer screening in Greece. Eur J Cancer 2000;36:2227–32.
89. Schnippel K, Lince-Deroche N, van den Handel T, Molefi S, Bruce S, Firnhaber C. Cost evaluation of reproductive and primary health care mobile service delivery for women in two rural districts in South Africa. PLoS One 2015;10:e0119236.
90. Alexy BB, Elnitsky C. Rural mobile health unit: Outcomes. Public Health Nursing 1998;15:3–11.
91. Craddock FG, Husain OA. A mobile cancer screening service. Nursing Mirror Midwives J 1975;141:48–50.
92. Seacome M.The use of a mobile unit for screening for cervical and breast cancer. Minerva Ginecol 1971;23:387–90.
93. Whitfield A.The mobile unit campaign for cervical cytology in Hackney–1969. Nurs Times 1970;66:17–9.
94. Lynch HT, Brodkey FD, Guirgis HA. Survival data from a multiphasic mobile cancer detection unit. Oncology 1976;33:179–82.