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Cervical cancer screening guidelines and screening practices in 11 countries: A systematic literature review

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ABSTRACT

The World Health Organization (WHO) advocates population-based screening programs to reduce the global incidence of cervical cancer. However, screening guidelines and practice continually change to reflect scientific developments. Here we describe and compare cervical cancer screening guidelines and clinical practice in 11 countries across North America, Europe, and Asia-Pacific. We conducted a systematic literature review (SLR) complemented by a targeted literature review (TLR) to identify relevant peer-reviewed publications and policy documents, which include 120 publications, of which 86 were identified from the SLR and 34 from the TLR. Only six of 11 countries assessed have population-based screening programs in place. Considerable differences persist across countries' screening guidelines, even among comparable systems. Moreover, methods of data collection are also heterogenous, and systematic data collection is often not established. As future changes in screening guidelines and clinical practice occur (e.g., when the first cohorts of women vaccinated against HPV reach screening age), systematic collection of screening data is essential to monitor and improve screening performance.

1. Introduction

As the fourth most common cancer in women, cervical cancer was responsible for 342,000 deaths worldwide in 2020, according to World Health Organization (WHO) estimates (World Health Organization, 2022). The WHO reports that there were 604,127 newly diagnosed cases in that same year (World Health Organization, 2020). Human papillomaviruses (HPVs), a group of double-stranded DNA viruses, are the main cause of cervical cancer. HPV is the most common sexually transmitted infection (World Health Organization, 2020); however, not all of the more than 100 types of HPV are linked to cervical cancer (Chrysostomou et al., 2018; de Martel et al., 2017). The oncogenic types HPV16 and 18 together cause approximately 70% of all cervical cancers (Chrysostomou et al., 2018 Dec 19).

Cervical cancer can be avoided through primary and secondary prevention measures. Vaccination against HPV disease—the first HPV vaccine launched in 2006—is a primary preventive measure, and screening is a secondary one (World Health Organization, 2020; de Martel et al., 2017). Vaccines today cover HPV types that are related to approximately 90% of all cervical cancers (Chrysostomou et al., 2018). Screening for cervical cancer developed in the 1940s and 1950s with the introduction of the Papanicolaou (Pap) test (Ngan et al., 2011). The Pap test became the primary method to screen for cervical cancer and is largely responsible for its reduced incidence (Chrysostomou et al., 2018; Lowy et al., 2008). An alternative to the Pap test is liquid-based cytology (LBC) (Chrysostomou et al., 2018), one advantage of LBC compared with the Pap test is that it can be used for further examinations, e.g., HPV testing (Chrysostomou et al., 2018; Siebers et al., 2009). HPV-based screening, which aims to detect oncogenic HPV DNA and HPV mRNA that can lead to precancerous lesions and cancer (Chrysostomou et al., 2018), has greater sensitivity regarding the detection of pre-cancerous lesions compared with cytology-based testing, resulting in a reduced burden of cervical cancer (von Karsa et al., 2015).

With the *Global Strategy to Accelerate the Elimination of Cervical Cancer as a Public Health Problem*, the WHO advocates, among other measures, implementing population-based screening programs to reduce the

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incidence of cervical cancer globally (World Health Organization, 2020; von Karsa et al., 2015). In a population-based program, women in the target population are identified and invited—e.g., via invitation letter—to receive cervical cancer screening. By contrast, opportunistic screening programs require that the patient or her doctor take the initiative for the patient to undergo regular cervical cancer screening as recommended in relevant clinical guidelines. Establishing an effective population-based screening program requires a policy guideline that defines the organization of the program (e.g., how women are to be invited), the type of test that should be applied, the age range of the target population, the screening interval, and follow-up screening and treatment modalities in the case of a positive test result (Arbyn et al., 2010). Also needed are quality assurance as well as monitoring and evaluation (e.g., with national registries) (Arbyn et al., 2010; Anttila et al., 2015). To fully understand the impact of cervical cancer screening on disease outcomes, examining screening guidelines and their implementation is essential.

Therefore, the goal of our research was to identify and summarize screening guidelines and practices in 11 countries across North America, Europe, and Asia-Pacific. Toward these ends, we conducted a systematic literature review (SLR) of peer-reviewed publications complemented by targeted searches for relevant policy documents.

2. Methods

An SLR was conducted to identify relevant peer-reviewed publications on cervical cancer screening guidelines and practices in Canada, the US, France, Germany, Italy, Spain, Sweden, the UK, Australia, China, and Japan. The searches were executed in Embase, Medline, and Cochrane. In addition, targeted searches of gray literature were performed to complement the SLR by identifying screening guidelines and policy documents not commonly published in peer-reviewed journals. Rather, they can be found on the websites of governments, national health authorities, or medical societies.

The PICOS criteria (population, interventions, comparators, outcomes, study design) were used to identify relevant publications from 2005 Jan-2021 Jan; further information is provided in the supplemental material (supplemental material Exhibit S1).

We chose to focus on a total of 11 countries across North America, Europe, and Asia-Pacific. We selected countries that have established guidelines, long-standing cervical cancer screening systems, and/or specific pilot screening programs and that have information on screening practices available. The literature review process was carried out by four different reviewers with the language skills appropriate to the studies and guidelines under review, with the exception being Japan; for this country, only publications in English were assessed for inclusion and extraction.

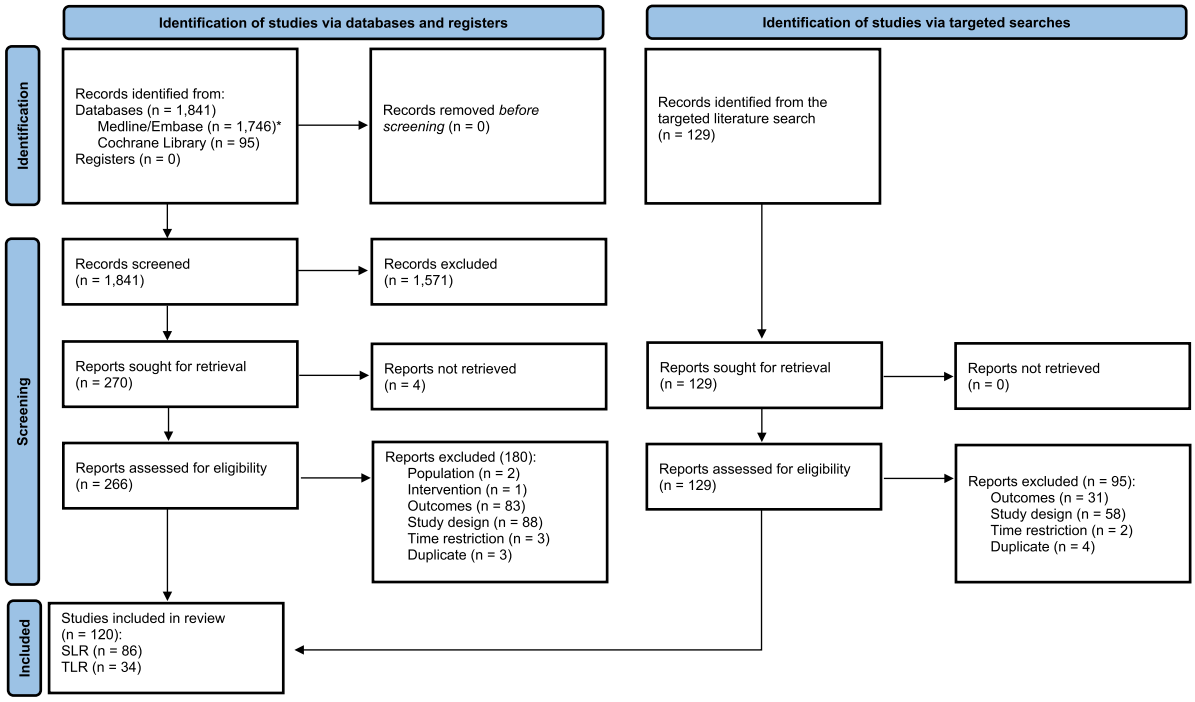
For the targeted literature review (TLR), the reviewers executed individual searches in the respective language on the websites of relevant national health authorities to identify guidelines, recommendations, and other information regarding screening systems in the individual countries or regions.

3. Results

3.1. SLR and TLR Results

The initial search was conducted on September 23, 2019, and an updated search was performed on January 6, 2021. A total of 120 publications were included; 86 publications resulted from the SLR and 34 from the TLR. The PRISMA flow diagram for the combined SLR and TLR is provided in Exhibit 1.

For each country included in the scope of our literature review, we extracted the most recent guidelines, as well as those that preceded them, to obtain an overview of changes in guidelines over time. Additionally, our extraction of national guidelines was complemented with globally and regionally issued recommendations, which were identified for the WHO at the global level (World Health Organization, 2022), and for the European Union (von Karsa et al., 2015; Arbyn et al., 2008) and Asia (Ngan et al., 2011) at the regional level. For North America, no



*Medline and Embase were searched simultaneously by ProQuest search engine.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

Exhibit 1. PRISMA 2020 flow diagram for new systematic reviews, which included searches of databases, registers, and other sources.

regional guidelines were identified. An overview of all extracted guidelines is provided in the supplemental material (supplemental material Exhibit S2). Of these global and regional guidelines, those from the European Union were the most extensive and detailed; in addition, they have direct influence on the national guidelines of member states. Therefore, EU guidelines are also described in this study.

3.2. Screening guidelines

3.2.1. US

In the US, there is no nationwide population-based screening program. The most prominent guidelines are those issued by the US Preventive Services Task Force (USPSTF, 2018), the American Cancer Society (ACS, 2020), the American Society for Colposcopy and Cervical Pathology (ASCCP, 2015), the American Society for Clinical Pathology (ASCP, 2012), and the Society of Gynecologic Oncology (SGO, 2015). Four sets of guidelines were identified (Exhibit 2) (Saslow et al., 2012; Huh et al., 2015; Bulletins-Gynecology ACoP, 2016; Curry et al., 2018; Fontham et al., 2020). Two guidelines recommend starting screening at age 21 (Saslow et al., 2012; Curry et al., 2018), while the other two recommend that screening commence at 25 and no younger (Huh et al., 2015; Fontham et al., 2020). Three of the four guidelines recommend a three-year interval for testing, whereas the ACS guidelines recommend a five-year interval (Fontham et al., 2020). All guidelines recommend using HPV tests and/or co-testing (HPV in combination with cytology testing) from the age of 30 on (Exhibit 3).

3.2.2. Canada

For Canada, a national screening guideline published by the Canadian Task Force on Preventive Health Care (CTFPHC, 2013) was identified (Exhibit 2) (Dickinson et al., 2013). The CTFPHC guidelines recommend cytology screening every three years from 25 to 69 years of age (Exhibit 3) (Dickinson et al., 2013). However, healthcare delivery and cervical cancer screening are the responsibility of Canadian provinces and territories; thus, diverse guidelines are applicable across the country. The identified provincial guidelines from British Columbia, Ontario, and Quebec differ from the recommendations made by the CTFPHC in their starting age of screening, screening interval, and screening type (Ontario's guidelines are the only ones recommending HPV-based screening) (Dickinson et al., 2013; Murphy et al., 2011; British Columbia Cancer Agency, 2016; Institut national de santé publique du Québec, 2011).

3.2.3. European Union

The first cancer screening guidelines at the EU level were issued in 1993 (Coleman et al., 1993), with updates following in 2008 (Arbyn et al., 2008) and 2015 (von Karsa et al., 2015). The EU recommends using population-based screening programs (Arbyn et al., 2008) and introducing HPV testing starting at the age of 30 with a five-year interval (von Karsa et al., 2015). EU guidelines aim to support and assist member states with high-quality cancer screenings (von Karsa et al., 2015). However, EU countries are not obligated to follow EU guidelines, as healthcare is the exclusive responsibility of each member state.

3.2.4. France

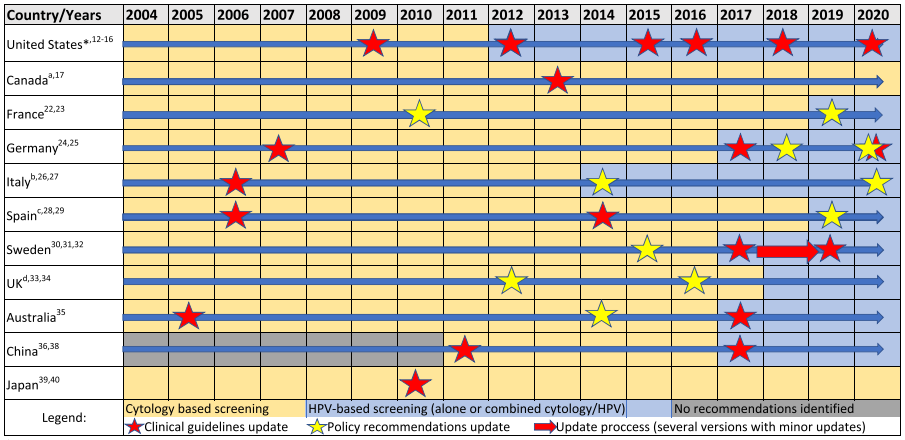
In 2018, a nationwide, population-based screening program established by regional coordination centers was introduced in France, replacing a mix of regional approaches that previously existed (Institut National du Cancer, 2019). The latest cervical cancer screening guidelines were issued by the Haute Autorité de Santé (HAS) in 2019 (Exhibit 2). They recommend two cytology tests with an interval of one year, starting at 25 years of age, and another cytology test after three years, followed by HPV tests every five years from 30 to 65 years of age (Exhibit 3) (Haute Autorité de Santé, 2019).

3.2.5. Germany

In Germany, a population-based cervical cancer screening program was introduced as of January 2020 (Gemeinsamer Bundesausschuss, 2018). Recommendations on screening practices are issued by the German Society for Gynecology and Obstetrics in collaboration with other medical societies (the latest published in 2020) and by the Federal Joint Committee (G-BA), with the latter conveying a legal claim for women to be screened according to the recommendations (Exhibit 2) (Gemeinsamer Bundesausschuss, 2018). Both guidelines recommend yearly cytology testing for all women from 20 to 30 years of age (Gemeinsamer Bundesausschuss, 2018; Leitlinienprogramm Onkologie, 2020). For women above the age of 30, G-BA guidelines recommend continuing yearly cytology testing and HPV+cytology co-testing (HPV + cytology) every three years (Gemeinsamer Bundesausschuss, 2018). However, recent clinical guidelines exclusively recommend HPV-based tests every three to five years up to 65 years of age (Exhibit 3) (Leitlinienprogramm Onkologie, 2020).

3.2.6. Italy

Cervical cancer screening in Italy has been established as a population-based program by national policy since 2014 (Exhibit 2), incorporated in the national prevention plan, 2020-2025 (Ministero



* In the US, there is no nationwide population-based cervical cancer screening program; thus, data on cytology or HPV-based screening implementation are based on data regarding the general uptake of screening tests.

a In Canada, some regions have their own guidelines that are more detailed than the national ones here presented.

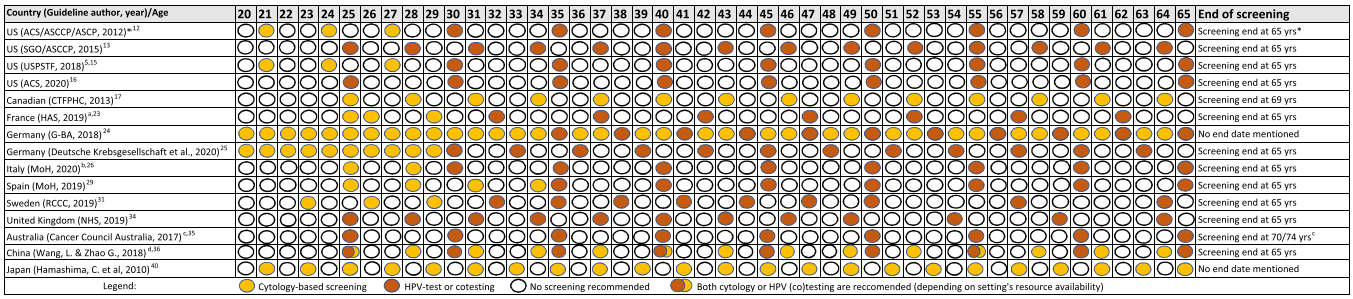
b In Italy, the legal strategic bases for the new screening guideline were set within the 2014 national prevention plan.

c In Spain, HPV-based screening was recommended in 2014 in the guidelines published by the Spanish Association of Cervical Pathology and Colposcopy (AEPCC).

However, we selected the 2019 official policy document developed by the MoH to be the official introduction of HPV-based recommendations nationally.

d In the UK, Wales implemented HPV-based screening in 2018; England, Scotland, and Northern Ireland initiated HPV-based screening in 2019/2020.

Exhibit 2. Development of Screening Guidelines Across Countries.



Abbreviations: ACOG, American College of Obstetricians and Gynecologists; ACS American Cancer Society; ASCCP, American Society for Colposcopy and Cervical Pathology; ASCP, American Society for Clinical Pathology; USPSTF, United States Preventive Services Task Force CTFPHC, Task Force on Preventive Health Care; G-BA, Gemeinsamer Bundesausschuss; HAS, Haute Autorité de Santé; MoH, Ministry of Health; RCCC, Regional Cancer Centers in Collaboration; DHSC, Department of health & Social care.

* ACS/ASCCP/ASCP (2012) guideline recommends that screening end at 65 yrs if the previous two co-tests were both negative.

& For women aged 30-65 years, the USPSTF (2018) guideline also recommends the option of cytology testing every three years in addition to HPV testing or co-testing every five years.

a In France, screening starts at 25 years. Cytology screening commences between 25 and 30 years: 2 examinations with an interval of 1 year; next screening after 3 years, if the first 2 screening results were normal. HPV test between 30 and 65 years: First HPV test 3 years after the last cytology test and then in 5-year intervals.

b In Italy, the information was taken from the website of the ministry.

c In Australia, discharge is at age 70–74 years if a screening test does not detect oncogenic HPV.

d In China, authorities recommend screening with a cytology test, via visual inspection with acetic acid, or HPV testing depending on the setting's specific resource availability. For women older than 65 years, screening can be stopped if, within the past 10 years, 3 consecutive cytology tests were negative (screening every 3 years), or if 2 consecutive HPV tests were negative (screening every 5 years).

Exhibit 3. Screening intervals and type of screening tests per country.

della Salute, 2020). The policy recommends cytology-based screening every three years from 25 to 30 years of age, followed by HPV-based screening every five years from 30 to 65 years of age (Exhibit 3) (Ministero della Salute, 2019).

3.2.7. Spain

In Spain, cervical cancer screening programs are organized at the regional and community levels, using a mix of population-based and opportunistic approaches following the 2014 recommendations of the Spanish Association of Cervical Pathology and Colposcopy (AEPCC) (Bladé et al., 2014), the Ministry of Health issued in 2019 official national screening guidelines for cervical cancer (Exhibit 2) (Ministerio de Sanidad Consumo y Bienestar Social, 2019). The guidelines recommend cytology-based screening every three years from 25 to 30 years of age, followed by HPV-based screening every five years from 30 to 65 years of age (Exhibit 3) (Ministerio de Sanidad Consumo y Bienestar Social, 2019).

3.2.8. Sweden

Sweden has had a nationwide, population-based cervical cancer screening program since 1973 (Pedersen et al., 2018). The latest changes to the program were made in 2017 (Regional Cancer Centers in Collaboration, 2019), following recommendations of the National Board of Health and Welfare (Socialstyrelsen) in 2015 to introduce HPV-based screening (Exhibit 2) (Socialstyrelsen, 2015). The guidelines recommend cytology-based screening every three years from 23 to 29 years of age, followed by HPV testing on a liquid-based cell sample every three years from 30 to 49 years of age, with an additional co-test (HPV plus cytology test) at age 41, and finally an HPV test on a liquid-based cell sample every seven years from 50 to 64 years of age (Exhibit 3) (Regional Cancer Centers in Collaboration, 2019). Implementation is the responsibility of regions, which also issue regional guidelines in accordance with national recommendations (Regional Cancer Centers in Collaboration, 2019).

3.2.9. UK

In the UK, a population-based cervical cancer screening program has been in place since 1988 (Albrow et al., 2012). In 2016, the UK National Steering Committee recommended an HPV-based test as the primary test within the screening program, which was implemented between 2018 and 2020 by the countries in the UK (England, Wales, Scotland, Northern Ireland) (Exhibit 2). The recommendations suggest performing HPV-based screenings every three years from 25 to 49 years of age, and every five years from 50 to 64 years of age (Exhibit 3) (National Health Service (NHS), 2015).

3.2.10. Australia

Since 1991, Australia has had a population-based Australian National Cervical Screening Program, with the latest updated guidelines issued in 2017 (Exhibit 2) (Cancer Council Australia, 2017). These guidelines introduced HPV testing every five years for all women between 25 and 69 years old and recommended self-sampling as part of the routine clinical practice, with the aim to increase participation rates of remote populations (Exhibit 3) (Cancer Council Australia, 2017).

3.2.11. China

In China, the "Comprehensive Prevention and Control Guidelines for Cervical Cancer in China," published in 2017, recommends cytology screening, visual inspection with acetic acid, or HPV testing (Exhibit 2) (Lin-hong and Geng-li, 2018). Screening should start between 25 and 30 years of age and can be stopped at the age of 65 years under certain conditions (Exhibit 3) (Lin-hong and Geng-li, 2018). As cervical cancer screening is opportunistic and organized at the regional level, screening programs and coverage are highly heterogeneous across regions in China (Ngan et al., 2011). Particularly in rural areas, screening rates are reported to be low at 16.9% (versus 29.1% in cities) (Aoki et al., 2020). Therefore, the Chinese government in collaboration with the Cancer Foundation of China and the All-China Women's Federation launched different initiatives to increase cervical cancer screening rates, including providing free screening to the target population (Ngan et al., 2011; Aoki et al., 2020; Wei Lihui et al., 2017).

3.2.12. Japan

Screening for cervical cancer is opportunistic in Japan and since 1998 the responsibility of prefectures and municipalities (Sauvaget et al., Jul 2016). Clinical screening guidelines have been established at the national level since 2010 (Exhibit 2) (Hamashima et al., 2010). The guidelines recommend screening any woman above the age of 20 with cytology-based screenings. HPV testing is not recommended (Exhibit 3) (Hamashima et al., 2010; Larson, 2020).

3.3. Characteristics of screening systems

Exhibit 4 provides an overview of screening system characteristics across countries. For each country, the table describes the screening program structure (opportunistic, organized, or mixed), the level of organization, and the methods of data collection and evaluation of cervical screening practices.

With regard to screening structures, neither the US nor Canada has a nationwide organized screening system in place nor structured and homogenous monitoring systems. In the US, the delivery of cervical cancer screening is largely the responsibility of individual medical

Countries	Screening structure	Organization	Monitoring: method of data collection
US[42,50]	Opportunistic^	Mixed*	**Registries, surveys and initiatives:** registries (e.g., NPCR and SEER) and surveys (e.g., NHIS and NCHS) are used; data are collected on a national level. Data collection is also done through research initiatives (eg,PROSPR I).
Canada[44,51]	Mixed$	Regional/Provincial	**Surveys and initiatives:** surveys (e.g., CCHS) and research initiatives (e.g., PCCSI) are used, data are collected at the national level.
France[46]	Organized€ - recent implementation	Regional/Provincial	**Sample database:** data from the general sample of beneficiaries (EGB) are used; EGB is a permanent and anonymous sample representing 1/97th of nationally social-insured and eligible persons; data are uploaded monthly.
Germany[24,52]	Organized€ since 2020 (before: opportunistic)	Health insurances#	**National cancer registry to be implemented:** until 2019, there was no systematic data collection at the country level. From 2020, screening data from regional statutory health insurances will be registered in a national cancer registry.
Italy[53]	Organized€ - recent implementation	National (program)/Regional (implementation)	**Surveys:** data collection relies on surveys performed yearly by the national screening observatory (ONS).
Spain[39,54]	Mixed$	Regional/Provincial	**Surveys:** data collection relies on surveys performed under national or European programs and collected by the National Statistics Institute (INE).
Sweden[48]	Organized€ – long-standing implementation	National (program)/Regional (implementation)	**Single registry:** data related to the screening program (invitations, results, follow-up) are integrated in the National Quality Register for Cervical Cancer Prevention (NKCx).
UK[33,34]	Organized€ - long standing implementation	National	**Single Registry:** screening data from the NHSCSP are routinely collected in a national registry.
Australia[35]	Organized€ - long standing implementation	National	**Single registry:** data related to the screening program are integrated in the National Cancer Screening Register (NCSR).
China[38]	Opportunistic	Regional/Provincial	Only specific studies performing data collection.
Japan[39]	Opportunistic	Regional/Provincial	**Reports:** annual compulsory health promotion activity reports on screening needs to be submitted by each municipality.

Abbreviation: CCHS, Canadian Community Health Survey; NCHS, National Center for Health Statistics; NHIS, National Health Interview Survey; NHSCSP, National Health Service Cervical Screening Program; NPCR, National Program of Cancer Registries; SEER, Surveillance Epidemiology and End Results; PROSPR I, Population-based Research Optimizing Screening through Personalized Regimens; PCCSI, Pan-Canadian Cervical Cancer Screening Initiative.
^Opportunistic screening refers to a system where someone needs to ask their doctor or health professional for a check or test, or a check or test is offered by a doctor or health professional.
€Organized screening refers to a system where an explicit screening policy, defined target population, implementation team, health care team for clinical care delivery, quality assurance infrastructure, and method for identifying cancer outcomes are in place.
$Mixed screening refers to screening systems in countries where a mix of opportunistic and organized screenings exist depending on the region/province. For example, in Canada and in Spain, the delivery of cervical screenings is the responsibility of each province/region. In both countries, some but not all the provinces have organized screening systems in place
*In the US, delivering cervical cancer screening and encouraging participation are largely the responsibility of individual medical practitioners, operating in the context of a mix of federal, state, and local programs; public and private health insurance plans; and medical specialty organizations that issue their own clinical guideline recommendations.
#In Germany, the delivery of cervical screenings is the responsibility of health insurances that are present across the country. Every insurance is responsible for the roll-out of the screening programs for their respective insured.

Exhibit 4. Screening practices characteristics — screening structure, organization, and data collection — across countries. (See above-mentioned references for further information.)

practitioners operating in the context of federal/state/local programs or public/private health insurance plans (Exhibit 4). Nonetheless, screening rates in the US are among the highest across the investigated countries (Healthy People 2020, 2020). However, unindicated screening in women under 21 years of age also remained high between 2012 and 2018 (Hosier et al., 2020). In Canada, some but not all provinces have put screening programs in place. Among the provinces, British Columbia and Ontario have established population-based screening programs (Murphy et al., 2011; British Columbia Cancer Agency, 2016). Participation rates differ across the country by province (between 64%-80%), with the highest screening rates being reported for provinces with organized population-based screening programs (Forte et al., 2012).

Spain is the only European country among the ones analyzed in this study that does not have an organized screening system (von Karsa et al., 2015). In both Italy and Sweden, the screening program is set at the national level, while implementation is up to each region. Both countries have launched HPV-based screening, which has been implemented in several but not all regions (Maver and Poljak, 2020). Germany and France recently implemented a nationwide organized screening system. In Germany, the organization of the screening program is the responsibility of the health insurances (Krankenkassen), which are responsible for sending invitation letters every five years to women

eligible for cervical cancer screening. Only recently has a single national registry been implemented. In France, screening programs are organized locally and a sample database (representing 1/97th of nationally socially insured people) is uploaded with data monthly (Exhibit 4) (de Rycke et al., 2020). Overall, screening rates in Europe vary greatly, from about 29% reported in Italy (2012) to 79% in Sweden (2018) (Ronco et al., 2015; Kvalitetsregister, 2019). However, due to the heterogeneity in data collection, the comparability of these screening rates is limited.

Similar to Sweden and the UK, Australia has a long-standing national screening program with a single national registry that monitors screening practices (Exhibit 4). Nonetheless, despite the quick adoption of HPV-based screening, the change in screening practice introduced by the 2017 guidelines led to delays in screening of women, mostly due to increased colposcopy referrals, limited access to the National Cancer Screening Register, a more complex primary screening approach, and issues with the newly introduced self-collection option (Dodd et al., 2019).

China and Japan do not have nationwide organized screening practices in place, with both countries mostly relying on opportunistic cytology-based screening (Wei Lihui et al., 2017; Sauvaget et al., 2016). Screening rates are low in both countries. In China, reported rates range between 16% in rural regions and 29.1% in more developed areas (Wei Lihui et al., 2017). For Japan, screening rates are around 40% (Aoki et al., 2020).

4. Discussion

This literature review summarized the screening practice and guideline in 11 countries across North America, Europe, and Asia-Pacific, among which Sweden, the UK, and Australia have a longer history of national screening guidelines. Countries started to introduce HPV testing from 2012, beginning in the US with a 5-year screening interval (Saslow et al., 2012). Other countries then followed implementing HPV-based screening except Japan (Exhibit 2) (Hamashima et al., 2010).

Differences identified across national screening guidelines are mainly reflected in: screening start and end age, screening intervals, and primary screening methods. The majority of national guidelines recommending screening to begin at 25 years of age, but countries like Germany and Japan recommended a younger starting age at 20 years (Exhibit 3). Similarly, the majority of national guidelines recommend to terminate regular screening at the age of 65, except Canada (69 years) (Dickinson et al., 2013) and Australia (70-74 years) (Cancer Council Australia, 2017). With regard to screening intervals, recommendations are more heterogenous and often related to the type of testing recommended.

Regarding screening method, recommendations for cytology testing are associated with a shorter interval from yearly screening to every three years, while HPV testing is recommended every three or five years. For example, most guidelines in Europe recommend cytology-based screening every three years for women between 25 (or 23 for Sweden) (Regional Cancer Centers in Collaboration, 2019) and 30 years of age and HPV-based screening or co-testing every three or five years thereafter until the age of 65. EU member states like France (Haute Autorité de Santé, 2010), Italy (Ministero della Salute, 2019), Spain (Ministerio de Sanidad Consumo y Bienestar Social, 2019), and Sweden (Regional Cancer Centers in Collaboration, 2019) tend to follow EU guidelines (von Karsa et al., 2015) closely. Similar recommendations are provided by two US guidelines, namely the SGO/ASCCP 2015 and ASC 2020 guidelines (Saslow et al., 2012; Curry et al., 2018). By contrast, guidelines from other countries (Australia (Cancer Council Australia, 2017) and the UK (National Health Service (NHS), 2015) and the other two US guidelines (Huh et al., 2015; Fontham et al., 2020) primarily recommend screening with HPV testing or co-testing every three or five years starting at age 25.

Compared to the countries described above, Germany, Japan and China have larger differences in guidelines. To date, all women aged ≥20 years can receive yearly cytology testing in Germany (Gemeinsamer Bundesausschuss, 2018) and every other year in Japan (Hamashima et al., 2010). In China, cytology-based screening, visual inspection, and HPV testing are the recommended screening methods to accommodate differing resource availability, e.g., in rural versus urban areas (Lin-hong and Geng-li, 2018). Similar results have been reported in other recent reviews (Hu et al., 2021).

Our review revealed that six of 11 countries from North America, the EU and Asia-Pacific assessed in this review have an organized population-based screening program in place. Even fewer countries, only four out of 11, have a single nationwide registry in place to monitor screening practices. Countries change their screening guidelines and practices over time in response to the development of new prevention methodologies. Moving forward, it is expected that further screening guideline changes will occur as the first cohorts of vaccinated women reach screening age, and more evidence on HPV vaccination effectiveness and its impact on cervical cancer incidence and the anticipated performance characteristics of screening programs become available (Drolet et al., 2019).

Consistent and complete collection of data on screening participation and outcomes is essential to monitor and optimize the performance of cervical cancer screening. For countries with a long-standing population-based screening program—namely, Australia, Sweden, and the UK—consistent and complete data on screening participation and outcomes are routinely collected in a single national registry to monitor the quality and effectiveness of screening services (Landy et al., 2016; Rebolj et al., 2019; Wang et al., 2020).

Screening registries allow screening program optimization and can inform future screening policy changes, particularly in relation to HPV vaccination. As the first cohort of HPV-vaccinated women will shortly enter screening age in many countries, it is essential to have adequate data systems in place to understand the impact of vaccination on screening performance. However, systematic and uniform data collection is often not in place within opportunistic screening practices, nor is it in provincially organized screening. One example is Canada, where the absence of a central registry of screening and immunization records has impeded the determination of optimal screening programs for vaccinated cohorts (Malagón and Franco, 2019). By contrast, several studies have reported the use of national registries to evaluate the impact of HPV vaccination on cervical screening performance (Beer et al., 2014; Kreusch et al., 2018; Palmer et al., 2016; Palmer et al., 2019; Lei et al., 2020).

Changes in technologies, practices, and guidelines for cervical cancer prevention create a need to survey the current status and anticipate future changes in guidelines and practices. This prompted our research and likewise may have inspired other researchers who have recently reported similar literature research, although that research is different from ours in terms of approach, focus, level of detail, and regional scope (Maver and Poljak, 2020; Liverani et al., 2020). Maver and Poljak summarized the status of implementation of primary HPV-based cervical cancer screening in selected European countries in 2019, based on sources of literature, personal communication with experts, and national websites (details on the method of review were not provided) (Maver and Poljak, 2020). The authors concluded that cervical cancer screening policies across Europe varied greatly in 2019 and urge policymakers to transition to population-based HPV screening where it is not already in place (Maver and Poljak, 2020). Liverani and colleagues conducted a literature search on national and international cervical cancer screening guidelines with the aim of understanding what led to the introduction of the HPV test in screening programs and different screening strategies across the world (Liverani et al., 2020). Furthermore, the authors discussed the future of risk-based guidelines, in which full HPV genotyping could enable personalized clinical management of screened women depending on the oncogenic risk associated with the different genotypes, with reference to 2019 ASCCP guidelines (Perkins et al., 2020). Those

guidelines have defined clear CIN 3+ risk thresholds to guide management. The risk thresholds remain constant and the guidelines can thus adjust for new (future) test methods and new data, such as the expected decrease in CIN 3+ risk as more individuals who received HPV vaccination reach screening age. While the 2019 ASCCP guidelines address the management and follow-up of cervical screening abnormalities, a need also exists for changes in guideline recommendations for routine primary cervical cancer screening, as the lifetime CIN3+ risk and the performance of current cervical cancer screening will decline due to vaccination. De-intensification of screening programs, starting at an older age and with longer screening intervals, is suggested in settings with high vaccination coverage (Drolet et al., 2019; Inturrisi et al., 2021). However, studies providing robust data to inform future decisions on the modification of cervical cancer screening programs are needed.

The strength of our study is its combination of an SLR with targeted searches to identify both peer-reviewed publications and policy documents on screening guidelines and systems. A limitation of our study is that in focusing on 11 countries, it does not capture guidelines and practices in developing countries, whose screening guidelines are shaped by limited resources, as described by Ngan et al. (Ngan et al., 2011). Many developing countries around the globe are increasing efforts to implement screening programs (World Health Organization, 2020; Cubie et al., 2017). Further research is needed to evaluate the development and implementation of guidelines in, e.g., low-income countries. Another limitation of this SLR is its restriction to literature published from 2005 forward. But we inferred that current cervical screening policies and practices do not date back longer than 15 years. Furthermore, 15 years is a sufficient time in which to look for trends in the evolution of cervical cancer screening practice, e.g., regarding HPV vaccination. This study did not focus on decision-making processes and frameworks for guideline development, which have been examined elsewhere (Richter Sundberg et al., 2017; Basu et al., 2018).

6. Conclusion

Our research found that cervical cancer screening guidelines are ever-changing in response to new evidence as it becomes available. Future changes in guidelines and screening practice are expected as the first cohorts of vaccinated women reach screening age. A robust screening data infrascture, like a national screening registry, is an important factor to evaluate and improve the cervical cancer screening program across countries.

Author contributions

WW, EA, AS, KH, NH, and SK contributed to the design, planning, and conduct of the study, as well as to the analysis and interpretation of results and the drafting and revising of the manuscript.

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Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Wang Wei, Smita Kothari, and Anushua Sinha are full-time employees and stock owners of Merck Sharp & Dohme Corp., a subsidiary of Merck & Co., Inc., Kenilworth, NJ, USA. Emanuele Arcà and Kristina Hartl are full-time employees of OPEN Health. Natalie Houwing was a full-time employee of OPEN Health at the time the study was conducted. OPEN Health received funding from Merck Sharp & Dohme Corp. for conducting the study.

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Appendix A. Supplementary data

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