Achieving equity in cervical cancer screening in low- and middle-income countries (LMICs): Strengthening health systems using a systems thinking approach

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A B S T R A C T

The World Health Organization (WHO) is leading a call to action to eliminate cervical cancer by the end of the century through global implementation of two effective evidence-based preventive interventions: HPV vaccination and cervical screening and management (CSM). Models estimate that without intervention, over the next 50 years 12.2 million new cases of cervical cancer will occur, nearly 60% of which are preventable only through CSM. Given that more than 80% of the cervical cancer occurs in low- and middle-income countries (LMICs), scaling up sustainable CSM programs in these countries is a top priority for achieving the global elimination goals. Multiple technologies have been developed and validated to meet this need. Now it is critical to identify strategies to implement these technologies into complex, adaptive health care delivery systems. As part of the coordinated cervical cancer elimination effort, we applied a systems thinking lens to reflect on our experiences with implementation of HPV-based CSM programs using the WHO health systems framework. While many common health system barriers were identified, the effectiveness of implementation strategies to address them was context dependent; often reflecting differences in stakeholder’s belief in the quality of the evidence supporting a CSM algorithm, the appropriateness of the evidence and algorithm to context, and the ‘implementability’ of the algorithm under realistic assessments of resource availability and constraints. A structured planning process, with early and broad stakeholder engagement, will ensure that shared-decisions in CSM implementation are appropriately aligned with the culture, values, and resource realities of the setting.

1. Cervical cancer elimination goals: where do we stand?

Cervical cancer (CxCa) remains the fourth most common cancer diagnosed and cause of cancer death in women worldwide, with an estimated 569,847 cases and 311,365 deaths in 2018 (Ferlay et al., 2018). These numbers mask an enormous global disparity, with 87% of new cervical cancer cases and 91% of cervical cancer deaths occurring in low- and middle-income countries (LMICs). The high cervical cancer burden remains despite the availability of effective cervical screening and management (CSM) programs for more than 60 years. Modeling studies predict that more than 12 million cases of CxCa will occur over the next 50 years without rapid, global scale-up of prevention efforts, including broad coverage of highly effective human papillomavirus (HPV) vaccination and improved adoption of resource-adapted CSM programs (Simms et al., 2019).

In response to these dire predictions, in May 2018 the Director-General of the World Health Organization (WHO) called for the global elimination of cervical cancer in the next 100 years (elimination is
defined as an incidence of less than 4 cases per 100,000 women) (World Health Organization, 2013). An executive committee then developed a global strategy towards cervical cancer elimination, which included specific target goals: 90% coverage of HPV vaccination of girls (by 15 years of age); 70% coverage of screening (70% of women are screened with high-performance tests by the ages of 35 and 45 years) and 90% treatment of precancerous lesions; and management of 90% of invasive cancer cases (World Health Organization, 2013). Importantly, because immunization has limited efficacy in adult women already exposed to HPV before the vaccine was available, well over half of the predicted deaths over the next 50 years can be prevented only with improved screening and management strategies (Fig. 1) (Simms et al., 2019). Because high-income countries (HICs) are largely meeting elimination screening goals, rapid adoption and scale-up of sustainable CaCa screening in LMICs is essential for global advancement of this call-to-action.

Barriers to effective implementation of these vaccination, screening, and treatment programs have been identified and can be localized to nearly all levels of the health system. Technology has been developed and validated to address some of the service delivery barriers. However, effective reduction in cervical cancer burden requires BOTH evidence-based screening and treatment interventions (with or without intervening triage and diagnostic procedures) AND high participation across the care cascade. Technology and tools can only be effective in reducing cancer mortality if they are broadly and sustainably used to screen at least 70% of the eligible population and manage (and when necessary, treat) 90% of screen-positive women through the CSM program. It is thus essential that CSM programs are developed that deliver the best care available given a realistic evaluation of resource needs and constraints. To this end, professional organizations have developed resource-adapted guidelines, which are aimed to help program planners select interventions that have proven efficacy in reducing cervical cancer burden and are feasible to deliver under current or projected resource availability and stakeholder acceptability (World Health Organization, 2013; Jeronimo et al., 2017).

Many demonstration projects and pilot studies have shown that multiple strategies can be successfully deployed for delivery of CSM programs that are adapted to a variety of contexts (Fig. 2) (Arrossi et al., 2017; Campos et al., 2019). For example, molecular screening for high-risk HPV (hereafter referred to as HPV) has potential service delivery and acceptability advantages to alternatives that rely on morphology-based (vs. molecular-based) screening. Some of these advantages include the ability to: (1) use self-sampling in the community or health facilities for primary screening which increases coverage (an even more attractive option in a post-COVID-19 pandemic world), (Arbyn et al., 2018) (2) eliminate the need for speculum exams for 80–90% of women (lower cost, increased acceptability), (de Sanjose and Holme, 2019) (3) prioritize clinician-time for the most high-risk patients, (4) higher reproducibility due to increased objectivity of result, and (5) less intensive training requirements. In addition, screen and treat management strategies using ablative procedures eliminate the triage and diagnostic steps which may have the following advantages: (1) >80% of screen-positive women can be managed at the primary level by midwives, nurses or primary care doctors (de Sanjose and Holme, 2019) (2) reduced HPV prevalence in next screening round (virologic cure rates following ablative therapy of 75–90%), (Ogilvie et al., 2018) and (3) faster resolution of the positive test result increases acceptability among women (Holme et al., 2020). It is critical to note that these represent perceived advantages for CSM programs. Different stakeholders hold different opinions and beliefs, based on their training, lived experience, and personal values. Ultimately, CSM programs must be developed for every context, with broad stakeholder engagement to ensure that shared-decisions in CSM program design are appropriately aligned with the culture, values, and resource realities of the setting (Gravitt et al., 2020; Pfadenhauer et al., 2017).

The implementation feasibility for HPV-based strategies and their perceived advantage (depending on context) is proven and backed by a robust evidence-base. The problem for global adoption of these strategies is an insufficient understanding of the barriers to scale-up and sustainability in each country or region, including the stakeholder’s belief in the quality of the evidence for a given CSM algorithm, the appropriateness of the evidence and algorithm to context, and the ‘implementability’ of the program under realistic assessments of resource availability and constraints (Brouwers et al., 2015). In 2007, Dr. Margaret Chan (then Director-General of WHO) made a statement that reflects well the state of CSM implementation:

“For the first time, public health has commitment, resources, and powerful interventions. What is missing is this. The power of these interventions is not matched by the power of health systems to deliver them to those in greatest need, on an adequate scale, in time. This lack of capacity arises...in part, from the fact that research on health systems has been so badly neglected and underfunded” (De Savigny and Adam, 2009).

Why does this health systems service delivery barrier lead to inequalities? When care is available only to those who can afford access to services that are available only outside of ‘weaker’ health systems, vulnerable populations are left out.

In this paper, we take a broad look at implementation of CSM across the seven ‘health systems building blocks’: governance, financing, human resources, information, medical technologies, service delivery, and people. We end with a conceptual model of CSM implementation in a health systems context, provide a summary of narratives describing our own experiences regarding opportunities and obstacles for CSM implementation across each domain, and end with optimism that these barriers, which are not unique to cervical cancer prevention and control, can be overcome. Elimination goals will be met if we as a community can follow the advice of a seminal systems thinker:

“We can’t impose our will on a system. We can listen to what the system tells us, and discover how its properties and our values can work together to bring forth something much better than could ever be produced by our will alone.”


CSM programs are complex, multilevel interventions, and thus scale-up and sustainability are best approached through a systems thinking lens. A 2009 WHO report outlined the advantages of using a systems-thinking approach to strengthen health systems and accelerate sustainable adoption of evidence-based, complex health interventions (De Savigny and Adam, 2009). Health systems are known to be dynamic and complex. When foundational supports are not established, scale-up and sustainability of implementation strategies are stymied. In contrast, when disease prevention and control program implementation strategies focus on improving the interactions and information flow between the system actors and institutions, health systems are able to anticipate and adapt, rather than react, to changes. The WHO’s proposed framework of health system building blocks describes six sub-systems that an intervention may flow through, react with, and impinge upon when implemented (Fig. 3). Implementation of CSM programs in LMICs to meet global elimination goals can be accelerated by creating a shared understanding of how each health system domain must plan, interact, implement, monitor, and adapt CSM strategies (Rehfuess et al., 2019).

3. Creating a shared understanding of CC-EDT implementation in public health systems: a narrative, experiential review

Implementation strategies are designed as interventions to increase the adoption of evidence-based health interventions, and may be targeted to individuals (patients or health care providers (HCPs), to organizations or systems, or both (i.e., multilevel interventions) (Chambers et al., 2013). Following a global trend to simplify CSM programs in resource-constrained settings, the WHO and others recommend introduction of primary screening by HPV testing if feasible or visual inspection with acetic acid (VIA) if not (World Health Organization, 2013; Jeronimo et al., 2017). Screen-and-treat programs, (World Health Organization, 2013; Jeronimo et al., 2017) where screen-positive women are directly treated (single- or two-visit approaches) with ablative therapy (if eligible) at the primary health facility, are also recommended where colposcopy and other triage or diagnostic service resources are limited (World Health Organization, 2013). HPV testing and VIA screening, with an array of possible management strategies, were designed to improve access, simplify processes, reduce loss-to-follow-up, and adapt to limited availability of expert physicians in many places with high cervical cancer incidence. There have been excellent studies and systematic reviews detailing demand- (patient level) and supply-side (service delivery-level) evidence for implementation scale-up and sustainability (de Sanjose and Holme, 2019; Adsul et al., 2017; Rahman et al., 2019; Musa et al., 2017; Tatar et al., 2018; Johnson et al., 2018; Nowakowski et al., 2020; Yang et al., 2019; Paige et al., 2019; Cubie and Campbell, 2020). Some of the key woman-level barriers identified included: lack of patient knowledge, education, and awareness; inability to pay; geographic access challenges; lack of social/family support; and gender roles and inequality. Service-level barriers identified included: health workforce shortages; lack of outreach; limited information technology and resources to ensure follow-up across the care delivery cascade; lack of financing; lack of data flow/information that allows providers to assess whether their patients reached an endpoint in care; lack of services which meet women’s needs; and lack of adequate provider-women communication and counseling tools and strategies. Several suggestions to overcome each of these barriers were provided, ranging from patient education (Thulaseedharan et al., 2019) to using electronic patient tracking systems (Arrossi et al., 2019; Zhang et al., 2020).

However, because standardized reporting criteria of implementation outcomes structured according to the health systems building blocks have not been widely used, many barriers (particularly those that can be politically sensitive) are not reported, and thus are absent from the evidence-base. Foundational implementation issues regarding leadership/governance and health financing are specifically under reported, yet these health systems foundations may represent intervention targets with the highest leverage to increase scale-up and sustainability in meeting elimination goals. To address this evidence gap, we surveyed our own experiences in implementation of HPV-based screening programs (with or without subsequent triage testing or colposcopy referral).
in Argentina, Kenya, Malaysia, Peru, and Zambia. We used a modified version of the Cochrane Effective Practice and Organization of Care (EPOC) taxonomy (Cochrane Collaboration, 2017) of health systems interventions as a reflexive device to ensure that the broader health system and interactions were considered in our summaries. Three members of the research team reviewed responses and major themes were informally identified. Below, we highlight some CSM implementation challenges within each health system domain or embedded in the interactions (or lack thereof) between the domains that were consistently observed. We intend for these to serve as examples highlighting the complexity of CSM implementation to reframe our implementation perspective and solutions through a systems thinking lens; we did not intend, nor claim, that this exercise represents a systematic or an exhaustive evidence review.

4. Cervical screening and management barriers by health system domain

4.1. Governance and leadership

Most countries surveyed in our experiential review had political support for policy changes and adoption of cervical cancer control programs, however a serious disconnect between national policy agendas and operational support (budget, training, implementation planning) at the regional/local level was a frequently noted barrier to scale-up and sustainability. In addition, it was noted that frequent changes in health care policy were associated with changes in political leadership and resulted in unstable leadership teams, requiring ‘back to the drawing board’ redundancies in policy development and implementation, negatively impacting scale-up and sustainability at the national level. Often, information was reported to flow disproportionately from the national level downward, with fewer opportunities in place for feedback, coordination, and adaptation. Regional/provincial governments are expected to comply with national policies, but mechanisms to encourage or enforce compliance were frequently absent, leading to
slow or no adoption of national policy. Other challenges included a lack of oversight and integration or coordination between governance structures at primary care versus hospital facilities, which impeded care coordination across the screening and management spectrum. There was a general diversity of opinions regarding the appropriate degree of centralization. For example, too much centralization as well as a lack of centralization in the accountability for training and accreditation of health professionals were both identified as important implementation barriers, highlighting the context-dependent nature of health system influences on system function. A lack of regulation regarding dual practice (Ferrinho et al., 2004) (also known as physician multi-employment), where health care providers operate part-time in the public system and part-time in the private health care market, is common in most settings and was reported to create problems with reduced availability of health professionals and conflicts of interest for public sector service delivery; impeding efforts to strengthen the public health system.

4.2. Health financing

In many, but not all contexts, the majority of screen-eligible women were insured through national health insurance or publicly funded public health service programs. There was diversity in centralization of financing for programs, with both national and regional responsibilities for financing different elements of the CSM program. There was often a dissociation between national CSM policies and the budgets provided/available to support service delivery, including a lack of regional/provincial engagement in setting operational budgets at the national level (both capital investments and recurring costs). As a result, it was typical that the actual financing available to deliver the CSM program was insufficient to meet policy objectives. In addition, frequent examples were noted where insurance policies and realized coverage across the CSM care cascade were significantly different. Reimbursement caps and requests for patients to absorb consumable costs for screening and management activities reflect a general insufficiency in operational financing of standard health care despite health systems designed for universal health coverage. A reliance on external loans (i.e., Inter-American Development Bank/World Bank) with short- or medium-term goals was identified as a barrier to autonomy and sustainability. HPV-based programs were uniformly compromised by procurement challenges of HPV test kits, instrumentation and other requisite consumables, including fluctuating exchange rates (prices are set in US dollars), which result in instability in program costs, impacting the sustainability of programs over the long term. In addition, a general lack of provision of simple costing tools for regional planners, which, together with the lack of price transparency mentioned below, posed a significant barrier to scale-up and sustainability.

4.3. Health workforce

The human resources required for CSM depend on the structure of the program. It was uniformly noted that screening, delivered at primary health facilities, must be feasible in the context of delivery of other care priorities including family planning, maternal and child health, and HIV care. However, there are a lack of tools to assist implementation planners in decision-making to ensure adequate resourcing and staffing of the CSM programs and integration with other disease control programs. Stability of a trained workforce in many regions was compromised due to high turnover and lack of consistency/durability of contracts for health care professionals. Primary care health professions in rural areas are responsible for delivering multiple services and when the workforce is insufficient, other services (e.g., labor and delivery) take precedent and impact the stability of cancer screening programs. Paradoxically, maintaining a trained workforce in these settings may reduce overall workforce availability, as health professionals are required to attend multiple training workshops when training opportunities are not coordinated across disease control programs. In urban settings, health care professionals often compensate for low and inconsistent payment or job security in the public sector through private practice activities (i.e., dual practice (Ferrinho et al., 2004)), which limit their availability in the public system. Training and utilization of community health volunteers/workers was a commonly cited supplement to the professional workforce in delivery of CSM programs, but reliability and turnover were noted in some situations, questioning the feasibility of this implementation strategy as a sustainable solution. Regional managers are critical for leadership and accountability of CSM program delivery, but are inconsistently trained and recruitment and retention in more rural areas is difficult. Task shifting (WHO, 2008) of care (especially treatment) from referral centers to the primary levels has been successfully implemented to address situations where more highly trained medical expertise (e.g., gynecology, pathology) is limited. However, acceptability of this strategy by professional societies has limited the effectiveness in some areas; sometimes this was overcome with the use of telemedicine for remote consultation. If task shifting is acceptable, strategies to ensure stability of a trained workforce will require updates to nursing and general medicine curricula to enable licensing for the new skills required for CSM delivery.

4.4. Medical products and technologies

Several research advances made in cervical cancer screening and treatment (e.g., self-sampling, portable ablative therapy) were tailored for more feasible delivery in resource-constrained settings. However, while intended advantages can be realized once the technology is in the hands of the health care provider, sustainable procurement and supply chain management remain serious barriers to scale-up and sustainability in all countries. Regulatory processes to select products (e.g., HPV tests) were not always centralized, and were reported to be cumbersome. Importation costs, storage (especially for time and temperature sensitive test kits), and distribution chains remain significant challenges in all countries. Reliance on local distributors appears critical to meet these demands, yet adds significantly to program costs (i.e., while an HPV test manufacturer may guarantee a $5 per test cost, the actual cost to the health system will likely increase 2–3 fold to cover the supply chain requirements). The lack of price transparency also severely limits the negotiating power for procurement, which can lead to inequities between countries. Requiring non-transparent negotiation for prices can also lead to concerns about conflicts of interest and corruption, hindering the tender process. Difficulties in ensuring ongoing maintenance and technical support for the required technologies (e.g., HPV tests/instruments, equipment and consumables for ablative therapies, information systems, etc.) were also reported often due to requirements for annual re-competition of service contracts. Accountability and protection against theft of supplies and instrumentation are essential. Some countries report electronic inventory systems to manage the supply chain, which if feasible within the general information technology infrastructure, may represent a high-level intervention to include in CSM programs. However, collectively, implementation of sustainable solutions to address these barriers in decentralized systems remains a challenge for most countries.

4.5. Health services

Several bottlenecks in service delivery that increase the burden placed on the patient were consistently reported, many of which are not relieved merely through the adoption of new technologies. A chronic underfunding of the public health sector is likely at the root of these barriers, as services are usually readily available in the private sector for those who can afford them; this is particularly relevant to preventive services such as cervical cancer screening. At a high level, it is important to determine whether CSM services are part of essential primary health care services, as this will dictate the human resources needed for
efficient and integrated service delivery. Specifically including CSM in the WHO Package of Essential Non-communicable (PEN) Disease Interventions for Primary Health Care could support the integration of programs into existing core services (World Health Organization, 2010). Often there is no capacity for scheduling appointments at either the primary or tertiary care levels; service is delivered as a “first-come, first served” process, resulting in patients showing up en masse in the early morning to register, often being turned away before care was received because of limited availability of doctors, equipment, etc. Alternatively, patients are asked to make appointments in person, requiring multiple visits in person just to be seen. The increased burden placed on the patient seeking preventive care undermines the trust in the system and likely contributes to low screening and follow-up rates. CSM operates in a care cascade, with women who screen positive requiring management and referral to follow-up care (triage or diagnostic testing and/or treatment). Communication structures to ensure completion of this care cascade are fragmented and informal (e.g., health care professionals communicate with each other and patients via WhatsApp). Patient navigators and use of mobile technologies (i.e., mHealth) are being tested (Arrossi et al., 2019; Okunade et al., 2020) though sustainability may suffer due to budgeting constraints, limited cellular/broadband in rural areas, and frequent change in phone numbers by patients. Referral services are often centralized in cities, and more rural populations must pay for their own transport if screening positive, limiting accessibility to completion of care. Outreach and education to populations, particularly through traditional healers and rulers, have been reported to be effective, particularly in remote regions (Musa et al., 2017). In general, services delivered through the primary health centers were reported to be more effective and sustainable compared with community campaigns and mobile screening, a slightly different perspective from the published literature (Huecho et al., 2020; Greenwald et al., 2017).

4.6. Health information

Many of the limitations reported above, including accountability and budget planning through routine evaluation of program indicators, inventory and supply distribution management, and patient navigation through the care cascade, all rely on an effective system for routine collection of the key indicators/information and broad accessibility of the information across the health system. Key performance indicators (e.g., percentage of eligible women screened, percent of positive screens receiving follow-up care, etc.) must be set according to the program design (e.g., screening at defined ages with HPV testing every 5 years, total time-in-system from sample collection to follow-up and treatment where needed <30–45 days, etc.). Often, basic census information is lacking, and thus informative monitoring and evaluation may be significantly compromised. While all countries report national health information systems, they are often not used consistently at the primary level. Because rural areas and primary health facilities may not have sufficient mHealth capacity (limited internet connectivity, data costs), hybrid paper/electronic reporting systems are common. However even in these cases funding for data entry limits completeness and timeliness of data entry. In addition, parallel systems for disease surveillance, reimbursement, disease-specific or laboratory registries are common, and the information across the health system. Key performance indicators (e.g., collection of the key indicators/information and broad accessibility of the information across the health system). Core features of systems thinking emphasize that system function is understood as a whole, and that systems are interconnected. There are three core principles for using a systems thinking approach to design CSM programs: (1) a clearly stated purpose of the CSM system, (2) understanding of the core elements or activities required to implement the entire system, and (3) understanding how the different elements, activities, and stakeholders interact and interconnect when implementing the CSM system. All CSM systems should be designed to maximize the purpose of the system (principle 1), which is ultimately to reduce cervical cancer incidence and mortality. Program managers should design CSM programs that deploy evidence-based screening and treatment interventions and ensure that they can be delivered with high quality performance to a majority of the eligible population. As discussed previously, there are many evidence-based screening and treatment interventions that could be combined in different screening algorithms, but there is simply no single algorithm or screening/treatment strategy that is ‘the best’. Rather than seeking to define a gold standard screening approach, program managers are well-advised to identify the best approach for their system and context; an approach that reflects an acceptable balance of trade-offs in cost, feasibility in implementation and quality, acceptability, and adoption by the health system and the screened women.

The ‘appropriate’ balance of these trade-offs will be highly context dependent, precluding any one-size-fits-all recommendation. However, the process used to facilitate context adaptation based on the three principles of systems thinking for program design is broadly applicable. The Integrative Systems Praxis for Implementation Research (INSPIRE) methodology (Gravitt et al., 2020) is one example of a stakeholder-driven process to understand a system context and design a strategy that leverages opportunities and mitigates bottlenecks associated with realistic resource constraints and non-modifiable barriers. Implementation of the INSPIRE context-adaptation strategy is best achieved through creation of international, national, and regional/local leadership teams (Fig. 4). These teams will ensure that screening and management algorithm choices are feasible and acceptable for the setting, and will tailor the implementation of the program activities to their particular system norms and practices. Table 1 summarizes key foundational roles and responsibilities from the international community, national policymakers, regional planners, and local service delivery anchored in the cultural and structural context of each community. Overlapping leadership teams can strengthen bi-directional planning, ensure that policies and resources match elimination goal demands as efficiently as possible, do not disrupt other key services, and allow continuous evaluation and adaptation as situations change (such as service disruptions from global infectious disease pandemics and natural disasters) (Gilson et al., 2014). While specific approaches to meet
implementation demands will differ according to context, our collective experience suggests that improvements to health information systems for both surveillance and patient management represent a high leverage implementation strategy in almost all health systems [reference Woo et al in this issue]. This holistic implementation approach may sound too complex and formidable, but it has been effectively used in global health (Wilkinson et al., 2018). Other broadly generalizable implementation strategies include the development and validation of simple and generalizable planning/communication/knowledge transfer tools to complement existing toolkits (World Health Organization, 2018) and training leadership teams to think systemically. We have a unique opportunity to apply systems thinking to develop learning collaboratives for cervical cancer elimination. Applying this to meet cervical cancer elimination goals would provide proof-of-principle of the effectiveness of the approach as an implementation strategy and a change in the paradigm of health care delivery from reactive to proactive and adaptive.

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### Table: Scaleable unit of implementation (health system) - Coordination of care/information: Roles/responsibilities

<table>
<thead>
<tr>
<th>Community</th>
<th>Primary Health Center/Clinic</th>
<th>Laboratory</th>
<th>Tertiary referral center</th>
<th>Information systems/HR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand for screening</td>
<td>Education, awareness, contextually adapted</td>
<td>Sample collection</td>
<td>Sample collection</td>
<td>Sample collection</td>
</tr>
<tr>
<td>Self-collection</td>
<td>Yes</td>
<td>Sample registration</td>
<td>Sample registration</td>
<td>Sample registration</td>
</tr>
<tr>
<td>Repeat in 3 years</td>
<td>HPV positive?</td>
<td>Yes</td>
<td>HPV positive?</td>
<td>HPV positive?</td>
</tr>
<tr>
<td>Refer for clinical evaluation and treatment</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Repeat HPV test 12 months</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Scheduling</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Data capture</td>
<td>Monitoring and evaluation</td>
<td>Electronic registry</td>
<td>Enroll patient in registry</td>
<td>Electronic registry</td>
</tr>
<tr>
<td>Sampling and registration</td>
<td>Result documentation</td>
<td>Test result documentation</td>
<td>Result documentation</td>
<td>Test result documentation</td>
</tr>
<tr>
<td>Result management</td>
<td>Abnormal cytology or biopsy</td>
<td>Abnormal cytology or biopsy</td>
<td>Abnormal cytology or biopsy</td>
<td>Abnormal cytology or biopsy</td>
</tr>
<tr>
<td>Treatment</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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![Fig. 4. Moving from algorithm to implementation: An example of implementation of an HPV screen-and-treat program. This graphic illustrates the significant amplification of implementation options, stakeholder involvement and interconnectedness when moving from a policy decision to implement a screening algorithm to operational service delivery of the algorithm in complex adaptive health systems. A: The Policy: Visual illustration of an HPV screen-and-treat algorithm or flowchart to depict ‘what’ is to be done in a cervical cancer prevention program based on this strategy. B: Service Delivery: Visual illustration of a swim-lane example of the operational details to depict ‘what, where, how, and when’ different activities essential for implementation of the algorithm depicted in (A). The flows in the swim-lane diagram represent patient, sample, and data movement and linkage requirements across health system sectors (swim-lane columns). Yellow circles represent operational decision points (i.e., examples of where different implementation strategies can be deployed depending on context). Blue clouds with down arrows represent the activities, which require registration to ensure linkage of patient information enabling surveillance and patient management to treatment. Clock icons represent need for scheduling and integration of activities at each health system level to ensure no disruption in delivery of other health services. C: Leadership teams: A graphic illustration of proposed implementation leadership teams to effectively integrate evidence-synthesis and policy decisions in (A) with effective operational and resource planning for sustainable implementation of the algorithm in a public health system. Proposed roles and responsibilities of the leadership teams are elaborated in Table 1. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

POC – point of care; HCP – health care professional.
Table 1
Sector-specific implementation planning and service delivery responsibilities and recommended global initiatives and research priorities to support these mandates for cervical cancer elimination.

<table>
<thead>
<tr>
<th>Level of responsibility</th>
<th>Specific responsibility</th>
<th>Recommended global initiatives &amp; research priorities</th>
</tr>
</thead>
</table>
| International           | • Develop cervical Cancer elimination (CCE) Global Health initiative to leverage additional financial and technical resources to support government program initiatives • Build coalitions with international (e.g. IDB/World Bank, PAHO) and national (e.g. faith-based organizations, NGOs, professional organizations) partners with clearly defined roles and responsibilities • Coordination with other UN agencies, as well as international banking agencies such as World Bank, FMI, BID, etc. • Develop strong advocacy plan and social media to increase demand for services • Provide clear guidelines for resource-appropriate CC-EDT program design • Support research and tool development to help regional planners match screening demand to needed resources according to CC-EDT strategy • Ensure equitable and affordable access to technology and training and developed specifically to meet unique demands in LMIC setting | • Set multilevel implementation support priorities for the Global Health initiative in CCE • Develop tools to determine minimal level of human and technical resources required for different CC-EDT strategies (i.e., define how many health professional-hours required to screen 10,000 women over 5 years with HPV testing under various management strategies). • International effort to negotiate pricing, importation, and maintenance of critical supplies and technologies • Pooled purchasing agreements to lower costs of consumable reagents (e.g., HPV tests) and equipment (e.g., thermocoagulators) • Develop and test strategies to use minimal level of human and time constraints, including any changes to national support required for equitable and quality service delivery • Find synergies and optimize service delivery across routine disease prevention and control programs • Create demand for services solutions. **Funding**

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**Declaration of Competing Interest**

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