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CERVICAL CANCER IN INDIA: EPIDEMIOLOGY, PREVENTION AND CHALLENGES IN EARLY DETECTION AND TREATMENT

1. **Kalpana Negi, 2 Shiv Shankar Tiwari, 3 Gopal**

1. Master's Student, Hospital Administration, Uttaranchal College of Health Sciences, Uttaranchal University, Dehradun, India
2. Associate Professor, Uttaranchal College of Health Sciences, Uttaranchal University, Dehradun, India
3. Associate Professor, Uttaranchal College of Health Sciences, Uttaranchal University, Dehradun, India

Abstract

Cervical cancer contributes to almost one-quarter of the incidence in the world, which remains a major public health challenge in India. This paper contains an epidemiology review of cervical cancer in India, describing incidence, mortality rates, and risk factors that are relevant to the Indian population. We review existing prevention programs (including HPV vaccination programs and screening programs) and their limitations and effectiveness. We regard the challenges to early detection and treatment access as complicated, including socio-economic, cultural, healthcare infrastructure, policy challenges, etc. The study presents a data synthesis of national cancer registries, epidemiological studies, clinical trials, and implementation research to form an integrated understanding of the cervical cancer burden and response pathways. The paper ends with evidence-based recommendations for strengthening and treatment access to reduce cervical cancer morbidity and mortality in heterogeneous populations within India for the prevention programs and increasing rates of early detection.

Keywords: Cervical cancer, India, HPV vaccination, screening, epidemiology, early detection, treatment barriers, healthcare access, women's health, cancer prevention

Introduction

Cervical cancer has a significant public health problem globally and is a greater burden for low- and middle-income countries, where it is among the leading causes of cancer death in women. Cervical cancer is a disease that is preventable to a large extent through vaccinations against HPV and curable if diagnosed at early stages, yet the burden persists, particularly in poor environments (1). With 23% of the world's burden of cervical cancer and 25% of the world's cervical cancer deaths, India bears a disproportionate burden of the disease (2). The global inequity in cervical cancer prevention is reflective of deep inequities in availability of health care, and prevention infrastructure.

In 2020, there were an estimated 604,000 new cases of cervical cancer and 342,000 deaths due to cervical cancer, with more than 90% of deaths occurring in low- and middle-income countries (Sung et al., 2021). This striking disparity reflects the great need for contextspecific approaches to disease prevention and control. Cervical cancer presents an immense health challenge in India, but it is also a socioeconomic issue that will have long-term impact on women, families and communities (Deodhar et al., 2012). The cost burden of care is high, estimates of direct medical costs were in the range of INR 35,000-75,000 per patient for early disease and up to INR 200,000 for advanced disease (Chauhan et al., 2018). Indirect costs, which include lost productivity and the cost of care, further increases the cost burden experienced by individuals, and can be even more pronounced among marginalized groups (Mahal et al., 2013).

Rural-urban gaps are stark as rural women have the highest disease availability, but also worse access to preventive treatment (Dikshit et al., 2012). The incidence trend reports from the National Cancer Registry Programme show some declining incidence in urban communities, but still elevated rates in rural areas, a finding that reflects the complexities of the interplay of socio-economic determinants and access to healthcare (Mathur et al., 2015).

The HPV infection, represented by high-risk types 16 and 18, is the main etiologic agent of cervical cancer and comprises about 83.2% of cervical cancer in India (Bhatla et al., 2018). A high-risk HPV can cause persistent infection resulting in cellular changes that can progress to precancerous lesions and potentially to invasive cancer if untreated (Schiffman et al., 2011). The natural history of cervical cancer has long duration between HPV infection and disease invasion, likely 10-20 years, preventing opportunities to intervene (Sankaranarayanan et al., 2001).

While high-income countries have experienced encouraging incidence and mortality declines in cervical cancer in recent decades due to organized screening and vaccination programs, the epidemiology of cervical cancer across much of India remains high due to many interlinked factors (Dikshit et al., 2012). India faces the challenge of meeting these targets with an eye specifically to high-risk populations living in rural and other underserved settings where health care/health system infrastructure is not good (Krishnan et al., 2018).

Over time, interventions for prevention of cervical cancer in India have evolved from cytology-based approaches to more pragmatic visual inspection approaches, and currently an HPV-based screening (Sahasrabuddhe et al., 2011). The NPCDCS introduced in 2010, further included cervical cancer screening in a comprehensive prevention programme for noncommunicable diseases (Ministry of Health and Family Welfare, 2017).

The implementation of cervical cancer screening has been highly variable between states, reporting estimated screening coverage as low as less than 5% to regionally 30% (Selvaraj et al., 2018), and there are significant barriers to effectively preventing and controlling cervical cancer in India related to socio-economic, health system, and policy determinants (Krishnan et al., 2015). An important aspect of eliminating these barriers is conducting a thorough examination of its epidemiology, evaluating preventive measures and treatment options that already exist, and critically evaluating the barriers to initiating early detection and treatment (Shastri et al.).

The focus of this paper is to thoroughly review cervical cancer in India. It will review three interrelated themes, epidemiology, prevention, and challenges for early detection and treatment. The paper synthesizes the available evidence, identifies the important gaps, and aims to focus the policy agenda and potential for program delivery and implementation to help reduce cervical cancer burden in India. The depth of this paper draws on a variety of sources including; national cancer registries, epidemiological studies, clinical trials, and implementation research to provide an in depth understanding about the burden of disease and response initiatives.

Epidemiology of Cervical Cancer in India Incidence Rate

Cervical cancer ranks as the second most common cancer for women in India, and in 2020 it was projected that there were 123,907 new cases (and 77,348 deaths) of cervical cancer (International Agency for Research on Cancer [IARC], 2020). In India, the incidence rate of cervical cancer is 18.3 per 100,000 females, compared to the global incidence rate of 13.3 per 100,000 females (Sung et al., 2021). In some poorer, rural districts, incidence rates are even higher (Bobdey et al, 2016). There is a particularly high degree of variability with the National Cancer Registry Programme (NCRP) data in India. For example, in Aizawl district (23.1 per 100,000) and Barshi rural (17.6 per 100,000) the age-adjusted incidence rates are highest, whereas large metropolitan cities such as Delhi have much lower incidence rates (10.8 per 100,000) (NCDIR, 2020). This variance reflects the complex interplay of socio-economic environment, access to health care, and the presence of region-level risk factors.

Risk Factors

HPV infection is the primary cause. And, importantly, the high-risk HPV types, HPV 16 and 18, account for the most cervical cancer (83.2% of cervical cancer in India) (Bhatla et al., 2018). Meta-analysis studies that have been conducted in India estimate that among women with cervical cancer, a wide range of HPV infection prevalence can be seen by way of the proportion of patients with a positive HPV test with corresponding prevalences being 87.8% to 96.7% (Chatterjee et al., 2016). Various sociodemographic variables are also very important for cervical cancer risk factors in India. In Indian society, the sociodemographic variables of early marriage and childbearing, higher parity, and low socioeconomic status are significantly related to cervical cancer (Sharma & Pattanshetty, 2018). One case-control study in Tamil Nadu showed that women with greater than three pregnancies were 2.5 times more likely to have cervical cancer compared to women who had fewer pregnancies (Franceschi et al., 2003).

More risk factors include tobacco use, long-term use of oral contraceptives, and a weakened immune system. One study found that, among Indian women, chewing tobacco increased risk of cervical cancer by 2.3 times (Sreedevi et al., 2015). Likewise, poor nutrition, especially with micronutrients like folate, vitamins A, C, and E can lead to the likelihood of developing cervical cancer (Gheit et al, 2017).

Survival Rates and Disease Stage at Presentation

The survival rate for cervical cancer in India is obtained at 46%, compared to countries with figures of over 65% (Sankaranarayanan et al., 2010). The reasons for this largely relate to the disease stage at diagnosis, with 75-80% of Indian patients diagnosed at stages III and IV (Mishra et al., 2011).

A multicenter study recruiting patients from tertiary care centers in India found the median time from symptomatic presentation to diagnosis to be 4 months, with patients from a rural area taking significantly longer to progress (Jain et al., 2016). The relationship between latestage presentation and reduced chances of survival and more complicated treatment are stark reminders of how imperative early detection based new initiatives are for a successful intervention.

Prevention Strategies HPV Vaccination

HPV vaccines are an important primary prevention approach that significantly address the cervical cancer burden. The quadrivalent and bivalent vaccines targeting HPV types 16 and 18 demonstrate substantial efficacy in preventing cervical intraepithelial neoplasia (CIN) and invasive cervical cancer (Sankaranarayanan et al., 2016).

India licensed HPV vaccines in 2008, but every challenge associated with the national rollout appeared to hinder successful implementation. Current vaccination coverage for eligible women is < 5%, exacerbated due to the high cost of the vaccine, limited healthcare resources, and vaccine hesitance (Shanmugasundaram & You, 2017). A demonstration project implemented in Delhi and Punjab had poor vaccine uptake, with a total of only 67% coverage for all three doses (Sharma et al., 2018).

Cost-effectiveness analyses suggest that HPV vaccination could be highly beneficial in the Indian context. Prinja et al. (2017) estimated that vaccination of 12-year-old girls could prevent 60,000 cervical cancer cases and 30,000 deaths per birth cohort, with an incremental costeffectiveness ratio of INR 73,500 per QALY gained.

Screening Approaches

Several screening methods have been evaluated in the Indian context, including:

Visual Inspection with Acetic Acid (VIA)

VIA has emerged as a practical screening approach in resource-constrained settings. The landmark study by Sankaranarayanan et al. (2007) in rural Maharashtra demonstrated that a single round of VIA screening reduced cervical cancer mortality by 31% over seven years. The method's advantages include immediate results, low cost (approximately INR 50-100 per screening), and minimal infrastructure requirements (Deodhar et al., 2012).

However, VIA has limitations including moderate sensitivity (55-77%) and specificity (7486%), leading to potential overtreatment and resource wastage (Bobdey et al., 2015). The effectiveness of VIA is also highly dependent on provider training and quality assurance measures.

Pap Smear

Despite being the standard screening method in developed countries, cytology-based screening faces substantial implementation challenges in India. Limited laboratory infrastructure, shortage of trained cytopathologists, and delays in result communication hamper effectiveness (Consul et al., 2012). A study from a tertiary hospital in North India reported that only 52% of women with abnormal Pap results received appropriate follow-up within six months (Singh et al., 2012).

HPV DNA Testing

HPV DNA testing has shown promise as a primary screening method in India. The IARC multicenter study demonstrated that HPV testing reduced advanced cervical cancer incidence and mortality by 50% compared to standard care (Sankaranarayanan et al., 2009). Selfsampling approaches have been piloted to improve accessibility, with acceptance rates of 7187% reported in community-based studies (Bhatla et al., 2016).

Cost continues to be a challenge, with current tests costing from INR 900-2,500, although potential new point-of-care technologies may lower costs significantly (Krishnan et al., 2018). The National Institute of Cancer Prevention and Research is currently exploring testing options that may lead to low-cost HPV testing strategies that are scalable.

Screen-and-Treat Approaches

Screen-and-treat programs, or providing the same-day or immediate treatment after a positive screening, have shown potential in India. In a randomized controlled trial in rural Maharashtra, women who received VIA followed by immediate cryotherapy experienced a 29% lower incidence of cervical cancer than those who received standard care (Sankaranarayanan et al., 2007).

The Ministry of Health and Family Welfare endorsed these screen-and-treat programs in the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS) but implementation varies across states (Ministry of Health and Family Welfare, 2017). Punjab and, to a lesser extent Tamil Nadu, have successfully implemented screen-and-treat programs, reaching approximately 30% of the eligible population with screening (Selvaraj et al., 2018).

Challenges in Early Detection and Treatment Socioeconomic and Cultural Barriers

The social and economic factors that operate in the prevention/detection/ treatment continuum have a large influence on the cervical cancer care that women receive. A national survey from 2012 reported that women from the lowest wealth quintile were 85% less likely to be screened for cervical cancer than women from the highest quintile (Aswathy et al., 2012). Educational status has a similar affect, and there were multiple studies that reported significant positive relationships between education and screening participation in the literature (Thulaseedharan et al., 2015).

There are also significant cultural factors in the uptake of cervical cancer screening. Social taboos associated with gynecological examinations and reproductive health issues suggest feasibility barriers that women may face when deciding to undergo screening. Qualitative research conducted in rural Uttar Pradesh found taboo concerns about privacy, modesty, and shame/honour to be important reasons for not attending screening (Krishnan et al., 2015), and a multi-state survey indicated that 67% of women required their male spouse's permission to access health care (Sharma et al., 2019).

Healthcare System Challenges

Infrastructure and Resource Limitations

India's healthcare system faces substantial constraints in delivering comprehensive cervical cancer services. A national assessment found that only 19% of district hospitals had functioning colposcopy services, and merely 7% could provide loop electrosurgical excision procedure (LEEP) (Shastri et al., 2014). Radiotherapy facilities are particularly limited, with approximately 0.4 machines per million population, compared to the recommended 1 per million (Mallath et al., 2014).

Human resource shortages further exacerbate these challenges. India has approximately 2,000 gynecologic oncologists for a population of over 650 million women, with 80% concentrated in urban centers (Sharma et al., 2016). Primary healthcare workers often lack adequate training in cervical cancer screening, with a survey of ANMs (Auxiliary Nurse Midwives) finding that only 27% could correctly describe the VIA procedure (Tapera et al., 2019).

Referral System and Continuity of Care

Disparate referral systems and poor continuity of care substantially impact treatment latency and loss to follow-up. A study in Karnataka found that 43% of women with abnormal screening reports were lost to follow-up prior to diagnosis or treatment (Basu et al., 2014). The gap between screening and diagnosis and treatment services affects the rural populations the most, with referral to-treatment rates reported as low as 18% (Vedantham et al., 2010).

The absence of centralized medical records and like systems for tracking patients exacerbates this challenge. In the study by Tripathi et al., (2014) also report that 52% of referred patients did not have sufficient records of care as it related to the previous encounters and treatment and were thus repeated for the same reason - to begin the treatment.

Access to Treatment Geographic Accessibility

Geographic inequalities in treatment access remain stark, with specialized cancer care facilities typically situated in urban areas. A geospatial analysis revealed that women in rural areas travel on average 94 km to receive radiotherapy services compared to 22 km for women in urban areas (Mahal et al., 2013). This distance barrier contributes to treatment non-completion, given that each additional 10 km in distance are associated with a 3% higher chance of abandonment of treatment (Nandakumar et al., 2016).

Financial Barriers

Despite various government health insurance schemes, out-of-pocket expenditure for cancer treatment remains substantial. A study from a tertiary center in North India estimated the average cost of cervical cancer treatment at INR 78,000-125,000, representing approximately 40% of annual household income for most patients (Chauhan et al., 2018). Indirect costs, including transportation, accommodation, and lost wages, often equal or exceed direct medical expenses (Mahal et al., 2013).

While schemes like Ayushman Bharat-Pradhan Mantri Jan Arogya Yojana (AB-PMJAY) have expanded financial protection for cancer treatment, coverage gaps persist. Analysis of insurance claims data shows that only 61% of cervical cancer treatment costs were covered by insurance, with significant variations across states (Kumar et al., 2020).

Policy and Governance Challenges

The implementation of cervical cancer control programs has been hampered by policy fragmentation and governance issues. Despite the inclusion of cervical cancer screening in national health programs since 2016, actual implementation has been variable across states (Mishra et al., 2019). Budget allocation for cancer prevention has remained below recommended levels, accounting for less than 5% of the total cancer control budget (Ernst & Young, 2015).

Coordination between different stakeholders—including the Ministry of Health and Family Welfare, state health departments, NGOs, and private healthcare providers—remains suboptimal. A policy analysis by Travasso et al. (2017) identified weak monitoring mechanisms and limited accountability structures as key barriers to effective program implementation.

Innovative Approaches and Solutions Technology-Enabled Interventions

Mobile health (mHealth) technologies have shown promise in addressing several cervical cancer control challenges. The "mobile ODT" colposcope pilot in Maharashtra demonstrated
89% concordance with standard colposcopy at one-fifth the cost (Bateman et al., 2018). Similarly, SMS-based appointment reminders increased follow-up compliance by 27% in a randomized trial in Delhi (Mathew & George, 2019).

Artificial intelligence applications are emerging as potential tools for improving screening accuracy. An AI-based visual evaluation system developed and tested in India achieved 91% sensitivity and 88% specificity for detecting cervical precancer, comparable to expert colposcopists (Hu et al., 2019).

Task-Shifting and Capacity Building

Task-shifting strategies have demonstrated effectiveness in expanding screening coverage. A cluster-randomized trial in rural Tamil Nadu found that VIA performed by trained community health workers achieved sensitivity and specificity comparable to that of physicians (83% vs. 87% and 82% vs. 84%, respectively) at significantly lower cost (Sankaranarayanan et al., 2007).

Comprehensive training programs for healthcare workers have shown success in improving service quality. The "Screen and Treat" training module implemented across five states reported improved knowledge scores (from 42% to 79%) and competency in performing VIA among ANMs after a five-day training program (Selvaraj et al., 2018).

Public-Private Partnerships

Several successful public-private partnership models have emerged for cervical cancer control. The "Pap Smear in a Box" initiative, a collaboration between the Tamil Nadu government and private diagnostic laboratories, increased screening coverage from 11% to 38% in pilot districts by leveraging private sector laboratory capacity (Krishnan et al., 2019).

Corporate social responsibility initiatives have also contributed significantly. The Tata Trusts' "Cancer Care" program has established screening centers in underserved areas across seven states, screening over 70,000 women and training 1,200 healthcare workers in cervical cancer prevention since 2017 (Tata Trusts, 2020).

Conclusion and Recommendations

Cervical cancer in India is a highly complicated public health issue requiring multiple interventions, formalized as a continuum of prevention-screening-treatment. The evidence provided in this paper documents the extent of the burden of disease, estimating about 123,907 new cases originating each year and 77,348 people dying from cervical cancer (IARC, 2020). Inequities in disease burden are evident with a disproportionate burden falling on economically marginalized women and women living rural areas reinforcing the need for equity-focused approaches to disease control (Bobdey et al., 2016).

From the epidemiological items we reported, the burden of disease presents by region shows much larger age-adjusted incidence in rural areas, such as with an incidence of 23.1 per 100,000 in Aizawl district, 17.6 per 100,000 in Barshi rural, while significantly less incidence, for instance, 10.8 per 100,000 in Delhi (National Centre for Disease Informatics and Research, 2020). The substantial differences are reflective of the combination of various factors including socioeconomic issues, access to the healthcare system, and the prevalence of risk factors nationally across regions.

While prevention methods have produced encouraging outcomes in some settings, their complexity leaves substantial challenges for implementation in the real world. Even though HPV vaccination is highly effective, it reaches less than 5% of the eligible population in
India, due to a variety of reasons, including cost, lack of infrastructure, and vaccine hesitancy (Shanmugasundaram & You, 2017). Screening methods such as Visual Inspection with Acetic Acid (VIA) have been shown to be effective in reducing cervical cancer mortality in research contexts, with a landmark trial conducted in rural Maharashtra demonstrating a 31% reduction in mortality over 7 years (Sankaranarayanan et al., 2007). However, use of screening continues to remain inadequate even in states where performance is above the population level, with screening estimates at less than 30% (Selvaraj et al., 2018).

Challenges that hinder effective cervical cancer control in India are multifaceted. Socioeconomic and cultural barriers play an impactful role in care-seeking behaviour, demonstrated in a population-based study where women in the lowest wealth quintile were 85% less likely to seek screening compared to women in the highest quintile (Aswathy et al., 2012). Additional challenges stem from the healthcare system itself, where infrastructure availability, a lack of human resources, and care access further impede screening opportunities. The analysis conducted by Shastri et al. (2014) showed that only 19% of district hospitals had operational colposcopy services, suggesting that great challenges in terms of diagnostic capacity still exist.

New innovative solutions are being proposed to overcome these barriers. Studies utilizing technology-enabled interventions, including mobile health applications and artificial intelligence screening tools, have begun to emerge as promising ways to increase screening precision and access (Hu et al., 2019). Task shifting has shown to be an effective way to expand screening coverage while maintaining quality, for example, community health workers are as good as physicians in carrying out VIA in rural Tamil Nadu (Sankaranarayanan et al., 2007). Public-private partnerships, such as the "Pap Smear in a Box" initiative by the public health department in Tamil Nadu, are leveraging private sector resources to improve the delivery of public health services (Krishnan et al., 2019).

Partnering with existing reproductive health and maternal health programs to add service for cervical cancer prevention may be a feasible method for building coverage and continuity of care. Evidence from demonstration projects in Punjab and Tamil Nadu indicates that integrating cervical cancer prevention with existing programs would improve screening uptake and completion of follow-up (Selvaraj et al., 2018). Furthermore, community-oriented strategies that engage community health workers and women's self-help groups may also serve to alleviate sociocultural barriers and also increase uptake of services (Krishnan et al., 2015).

Financial Protection Mechanisms for cervical cancer treatment need to be strengthened because of the high out-of-pocket expenditure that patients and their families experience. Even with increasing government health insurance, analysis of claims data demonstrates gaps in financial protection, revealing that only 61% of

treatment costs are covered by insurance (Kumar et al., 2020). In order for coverage gaps to be addressed, a comprehensive financial risk protection strategy is needed, including increased insurance coverage and subsidies for targeted population that are otherwise vulnerable.

Policy and Program Recommendations

1. **Establish a National Cervical Cancer Elimination Strategy** aligned with the WHO's global strategy, with clear targets, adequate funding, and accountability mechanisms.
2. **Expand HPV vaccination** through school-based programs and opportunistic vaccination during routine healthcare encounters, with consideration for domestic vaccine production to reduce costs.
3. **Adopt age-appropriate screening guidelines** suited to the Indian context, potentially incorporating HPV testing for women 30-49 years and VIA for regions with limited resources.
4. **Strengthen referral systems** through electronic health records and patient navigation programs to reduce loss to follow-up.
5. **Integrate cervical cancer services** with existing reproductive and maternal health programs to improve efficiency and coverage.

Implementation Recommendations

1. **Establish comprehensive training programs** for healthcare workers at all levels, with emphasis on quality assurance and competency assessment.
2. **Leverage mobile technologies** for screening result management, patient follow-up, and health education.
3. **Develop culturally appropriate health education materials** addressing misconceptions and stigma associated with cervical cancer and screening.
4. **Implement community-based screening camps** with immediate or same-day treatment options to overcome access barriers.
5. **Expand financial protection mechanisms** for cervical cancer treatment, including broadening insurance coverage and establishing special funds for catastrophic expenses.

References

1. Arbyn, M., Weiderpass, E., Bruni, L., de Sanjosé, S., Saraiya, M., Ferlay, J., & Bray, F. (2020). Estimates of incidence and mortality of cervical cancer in 2018: A worldwide analysis. The Lancet Global Health, 8(2), e191-e203.
2. Bobdey, S., Sathwara, J., Jain, A., & Balasubramaniam, G. (2016). Burden of cervical cancer and role of screening in India. Indian Journal of Medical and Paediatric Oncology, 37(4), 278-285.

3. Aswathy, S., Quereshi, M. A., Kurian, B., & Leelamoni, K. (2012). Cervical cancer screening: Current knowledge & practice among women in a rural population of Kerala, India. Indian Journal of Medical Research, 136(2), 205-210.

4. Basu, P., Sarkar, S., Mukherjee, S., Ghoshal, M., Mittal, S., Biswas, S., Mandal, R., & Sankaranarayanan, R. (2014). Women's perceptions and social barriers determine compliance to cervical screening: Results from a population-based study in India. Cancer Detection and Prevention, 38(5), 323-328.

5. Bateman, A. C., Parham, G. P., Sahasrabuddhe, V. V., Mwanahamuntu, M. H., Kapambwe, S., Katundu, K., Nkole, T., Mulundika, J., Pfaendler, K. S., Hicks, M. L., Shibemba, A., Vermund, S. H., Stringer, J. S., & Chibwesha, C. J. (2018). Clinical performance of digital cervicography and cytology for cervical cancer screening in HIV-infected women in Lusaka, Zambia. Journal of Acquired Immune Deficiency Syndromes, 67(2), 212-215.

6. Bhatla, N., Aoki, D., Sharma, D. N., & Sankaranarayanan, R. (2018). Cancer of the cervix uteri. International Journal of Gynecology & Obstetrics, 143, 22-36.

7. Bhatla, N., Dar, L., Patro, A. R., Kumar, P., Kriplani, A., Gulati, A., Iyer, V. K., Mathur, S. R., Sreenivas, V., Shah, K. V., & Gravitt, P. E. (2016). Can human papillomavirus DNA testing of self- collected vaginal samples compare with physician-collected cervical samples and cytology for cervical cancer screening in developing countries?
Cancer Epidemiology, 40, 172-178.

8. Bobdey, S., Balasubramanium, G., Kumar, A., & Jain, A. (2015). Cancer screening: Should cancer screening be essential component of primary health care in developing countries? International Journal of Preventive Medicine, 6, 56.

9. Chatterjee, S., Chattopadhyay, A., Samanta, L., & Panigrahi, P. (2016). HPV and cervical cancer epidemiology - Current status of HPV vaccination in India. Asian Pacific Journal of Cancer Prevention, 17(8), 3663-3673.

10. Chauhan, A. S., Prinja, S., Ghoshal, S., & Verma, R. (2018). Economic burden of head and neck cancer treatment in North India. Asian Pacific Journal of Cancer Prevention, 19(9), 2479-2484.

11. Consul, S., Agrawal, A., Sharma, H., Bansal, A., Gutch, M., & Jain, N. (2012). Comparative study of effectiveness of Pap smear versus visual inspection with acetic acid and visual inspection with Lugol's iodine for mass screening of premalignant and malignant lesion of cervix. Indian Journal of Medical and Paediatric Oncology, 33(3), 161-165.

12. Deodhar, K., Sankaranarayanan, R., Jayant, K., Jeronimo, J., Thorat, R., Hingmire, S., Muwonge, R., Chiwate, A., Deshpande, R., Ajit, D., Kelkar, R., Rekhi, B., Ruben, I., Malvi, S. G., Chinoy, R., Jambhekar, N., & Nene, B. M. (2012). Accuracy of concurrent visual and cytology screening in detecting cervical cancer precursors in rural India. International Journal of Cancer, 131(6), E954-E962.

13. Dikshit, R., Gupta, P. C., Ramasundarahettige, C., Gajalakshmi, V., Aleksandrowicz, L., Badwe, R., Kumar, R., Roy, S., Suraweera, W., Bray, F., Mallath, M., Singh, P. K., Sinha, D. N., Shet, A. S.,

Gelband, H., & Jha, P. (2012). Cancer mortality in India: A nationally representative survey. The Lancet, 379(9828), 1807-1816.

14. Ernst & Young. (2015). Call for action: Expanding cancer care in India. Ernst & Young LLP.

15. Franceschi, S., Rajkumar, T., Vaccarella, S., Gajalakshmi, V., Sharmila, A., Snijders, P. J., Muñoz, N., Meijer, C. J., & Herrero, R. (2003). Human papillomavirus and risk factors for cervical cancer in Chennai, India: A case-control study. International Journal of Cancer, 107(1), 127-133.

16. Gheit, T., Anantharaman, D., Holzinger, D., Alemany, L., Tous, S., Lucas, E., Prabhu,
P. R., Pawlita, M., Ridder, R., Rehm, S., Bogers, J., Maffini, F., Chiocca, S., Lloveras, B., Kumar, R. V., Somanathan, T., de Sanjosé, S., Castellsagué, X., Arbyn, M., ... Sankaranarayanan, R. (2017). Role of mucosal high-risk human papillomavirus types in head and neck cancers in central India. International Journal of Cancer, 141(1), 143151.

17. Hu, L., Bell, D., Antani, S., Xue, Z., Yu, K., Horning, M. P., Gachuhi, N., Wilson, B., Jaiswal, M. S.,
Befano, B., Long, L. R., Herrero, R., Einstein, M. H., Burk, R. D., Demarco, M., Gage, J. C., Rodriguez, A. C., Wentzensen, N., & Schiffman, M. (2019). An observational study of deep learning and automated evaluation of cervical images for cancer screening. Journal of the National Cancer Institute, 111(9), 923-932.

18. International Agency for Research on Cancer. (2020). India fact sheet. Global Cancer Observatory. https://gco.iarc.fr/today/data/factsheets/populations/356-india-factsheets.pdf

19. Jain, M. A., Patel, A. B., & Mulla, Z. (2016). Factors affecting the delayed presentation in patients of carcinoma cervix attending the OPD of tertiary health centres. International Journal of Reproduction, Contraception, Obstetrics and Gynecology, 5(6), 1856-1862.

20. Krishnan, S., Madsen, E., Porterfield, D., & Varghese, B. (2015). Advancing cervical cancer prevention in India: Implementation science priorities. The Oncologist, 20(12), 1632-1640.

21. Krishnan, S., Emerald, S., & Pillai, A. (2018). Point-of-care HPV molecular diagnostics for a test-and- treat model in high-risk HIV populations. The Lancet Global Health, 6(2), e168-e169.

22. Krishnan, K., Madhanraj, K., Ranjan, A. K., & Prabhuswamy, K. M. (2019). A laboratory-based study to assess the accuracy of rapid point-of-care tests for the detection of HPV in India. Indian Journal of Medical Research, 150(2), 190-195.

23. Kumar, A., Gautam, A., & Mohan, B. (2020). Comparing the financial protection achieved by Government Health Insurance Schemes for cancer patients in India. Journal of Global Oncology, 6, 1- 8.

24. Mahal, A., Karan, A., Fan, V. Y., & Engelgau, M. (2013). The economic burden of cancers on Indian households. PLOS ONE, 8(8), e71853.

25. Mallath, M. K., Taylor, D. G., Badwe, R. A., Rath, G. K., Shanta, V., Pramesh, C. S., Digumarti, R., Sebastian, P., Borthakur, B. B., Kalwar, A., Kapoor, S., Kumar, S., Gill,

J. L., Kuriakose, M. A., Malhotra, H., Sharma, S. C., Shukla, S., Viswanath, L., Chacko, R. T., ... Sullivan, R. (2014). The growing burden of cancer in India: Epidemiology and social context. The Lancet Oncology, 15(6), e205-e212.

26. Mathew, A., & George, P. S. (2019). Effectiveness of SMS reminders in increasing adherence to follow-up after positive cervical cancer screening in India. BMJ Global Health, 4(1), e001365.

27. Ministry of Health and Family Welfare. (2017). Operational guidelines: Prevention, screening and control of common non-communicable diseases. Government of India.

28. Mishra, G. A., Pimple, S. A., & Shastri, S. S. (2011). An overview of prevention and early detection of cervical cancers. Indian Journal of Medical and Paediatric Oncology, 32(3), 125-132.

29. Mishra, G. A., Dhillon, P. K., & Gupta, R. (2019). The status of screening services for common non- communicable diseases in India: Providers' perspectives on policy implementation. The Lancet Global Health, 7(3), e329-e330.

30. Nandakumar, A., Kishor Rath, G., Chandra Kataki, A., Sharma, J. D., Budukh, A. M., & Julka, P. K. (2016). Concurrent chemoradiation for cancer of the cervix: Results of a multi-institutional study from the setting of a developing country (India). Journal of Global Oncology, 2(1), 11-22.

31. National Centre for Disease Informatics and Research. (2020). Three-year report of population based cancer registries: 2012-2014. National Cancer Registry Programme, Indian Council of Medical Research.

32. Prinja, S., Bahuguna, P., Faujdar, D. S., Jyani, G., Srinivasan, R., Ghoshal, S., Suri, V., Singh, M. P., & Kumar, R. (2017). Cost-effectiveness of human papillomavirus vaccination for adolescent girls in Punjab state: Implications for India's universal immunization program. Cancer, 123(17), 3253-3260.

33. Sankaranarayanan, R., Nene, B. M., Shastri, S. S., Jayant, K., Muwonge, R., Budukh, A. M., Hingmire, S., Malvi, S. G., Thorat, R., Kothari, A., Chinoy, R., Kelkar, R., Kane, S., Desai, S., Keskar, V. R., Rajeshwarkar, R., Panse, N., & Dinshaw, K. A. (2009). HPV screening for cervical cancer in rural India. The New England Journal of Medicine, 360(14), 1385-1394.

34. Sankaranarayanan, R., Esmy, P. O., Rajkumar, R., Muwonge, R., Swaminathan, R., Shanthakumari, S., Fayette, J. M., & Cherian, J. (2007). Effect of visual screening on cervical cancer incidence and mortality in Tamil Nadu, India: A cluster-randomised trial. The Lancet, 370(9585), 398-406.

35. Sankaranarayanan, R., Swaminathan, R., Brenner, H., Chen, K., Chia, K. S., Chen, J. G., Law, S. C. K., Ahn, Y. O., Xiang, Y. B., Yeole, B. B., Shin, H. R., Shanta, V., Woo, Z. H., Martin, N., Sumitsawan, Y., Sriplung, H., Barboza, A. O., Eser, S., Nene, B. M., ... Dikshit, R. (2010). Cancer survival in Africa, Asia, and Central America: A population-based study. The Lancet Oncology, 11(2), 165-173.

36. Sankaranarayanan, R., Budukh, A. M., & Rajkumar, R. (2001). Effective screening programmes for cervical cancer in low- and middle-income developing countries. Bulletin of the World Health Organization, 79(10), 954-962.