

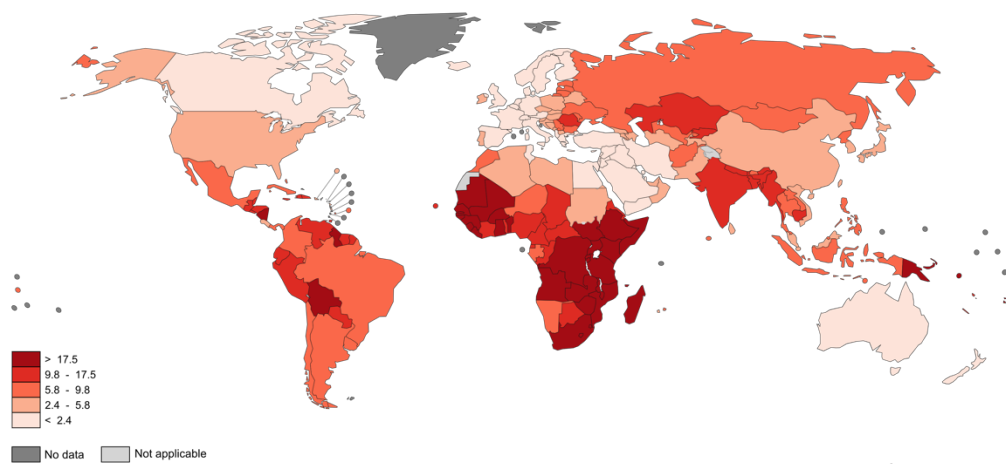
Developing an image-based features recognition algorithm to determine optimal treatment for
cervical cancer in low and middle income countries

Keerat Singh

The Academy of Science

Cervical cancer is a disease in which cells along the inner-lining of the lower uterus undergo pre-cancerous changes such as neoplasia and dysplasia (Peirson, Fitzpatrick-Lewis, Ciliska, & Warren, 2013). Cervical cancer is mainly caused by an infectious agent, Human Papilloma Virus (HPV). The two variations, HPV 16 and HPV 18, occur through unprotected sex, and cause over 70% of all cervical cancer cases (“Cervical Cancer,” 2016). All sexually-active women have increased chances of obtaining high risk HPV types, thus leading to increased chances for pre-cancerous cell changes. Other risk factors include smoking tobacco, experiencing past history with cancer, and taking the contraceptive pill.

Approximately 500,000 women per year are diagnosed with cervical cancer globally, and 275,000 of those patients die of the disease (Wieringa, Zee, Vries, & Vugt, 2016). The U.S. accounts for a very small percentage of that number (Siegel, Miller, & Jemal, 2015). From 1930 to 2011, cervical cancer mortality rates in the US have decreased over 80% due to medical advances. In low and middle income countries (LMIC), the rates have only reduced 6% from 1930 to 2011. As illustrated on the map below, developing countries such as Kenya, Ethiopia, and Bolivia have much higher mortality rates than developed countries, such as the U.S. and Canada.



The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

Data source: GLOBOCAN 2012
Map production: IARC
World Health Organization

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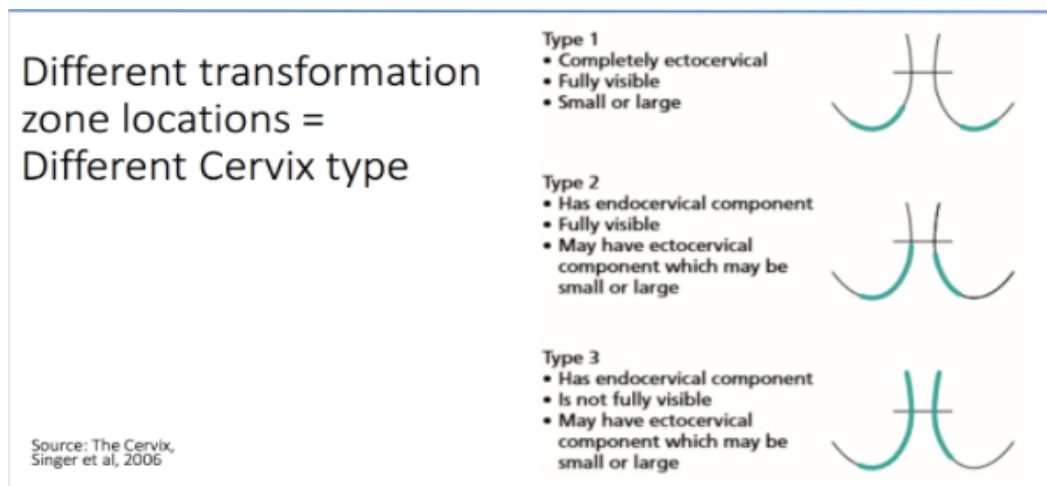
The U.S. has experienced a significant decline in cervical cancer mortality due to advancements in screening and treatment programs (Shulman, 2012). The introduction of Papanicolaou [Pap] diagnostic tests during the twentieth century, combined with the advancement of vaccines, drastically decreased the threat of cervical cancer. Recently, vaccines protecting against the growth of HPV are more expensive, yet more effective, with 90% success rates (McKee, Bergot, & Leggatt, 2015). The addition of L1 capsid proteins in the vaccine allow neutralizing antibodies to restrict and contain the HPV. When detected early, cervical cancer is one of the easiest diseases to treat, as it only requires a vaccine (Shulman, 2012). Other standard treatments for later stages of the cancer include surgery, radiation therapy, and chemotherapy (“Cervical Cancer Treatment,” 2016). The Pap test has allowed doctors in high-resource settings to detect pre-cancerous phenotypes in the cervix before the disease has developed, resulting in very few cases reaching stage I or higher (McKee, Bergot, & Leggatt, 2015). However, there is a large gap between advanced and LMIC countries for success when preventing and treating cervical cancer (Catarino, 2015). The lack of effective cytology-based screening programs in these low-resource settings is one of the biggest challenges in cervical cancer diagnosis (Saharabuddhe, Parham, Mwanahamuntu, & Vermund, 2011). The main causes of this are the widespread poverty of the countries, and poor training of the practitioners compared to developed countries (Catarino, 2015). Cytology screening requires consistent testing and medical attention that LMIC countries do not yet have the capacity to provide. Furthermore, countries in Eastern Africa and Southern America are also more susceptible to the disease due to unsanitary environments. Additionally, the inability to create an effective and population-wide vaccine allows the HPV to circulate freely (Saharabuddhe, Parham, Mwanahamuntu, & Vermund, 2011). Subsequently, the total number of diagnoses that detect cancer in its earliest

stages are about 60% lower than that of the U.S, leading to the need for more advanced and costly treatments downstream (Catarino, 2015).

To solve this problem, the majority of current research is focused on the analysis and implementation of more efficient screening programs in LMIC countries (Denny et al., 2017). Due to the relatively low medical experience of the practitioners, there have been numerous research projects that have looked into basic but equally-effective diagnosis techniques (Lee, Kang, Ju, 2016). For example, a large topic has been the use of acetic acid for a visual inspection test against the presence of HPV (Denny et al., 2017). Research has also been done with the replacement of acetic acid with Lugol's iodine (Vyas, Bhalodia, & Thakor, 2016). Both visual inspection techniques have had much more success in middle-income countries, such as parts of India and Pakistan. A large percentage of screening programs that are currently being looked into for LMIC countries aren't feasible; despite being reliable in terms of accuracy, they require complex human and financial infrastructures to be implemented and maintained (Lee, Kang, Ju, 2016). In Sub-Saharan Africa alone, it was reported in 2016 that less than 5% of at-risk women had been screened, indicating new screening programs' lack of implementation and success (Catarino, 2015). As a result, most cases of cervical cancer become invasive to the point that they are unable to treat. Many women in these parts of the world are receiving treatments that are ineffective and many times harmful to them ("Intel & MobileODT," 2017). Health providers often do not have the necessary skills, and more importantly, diagnostic resources, to recognize which treatments to use to prevent the spread of the cancer. The inability to discern which treatment will work for a woman based on her type of cervix has led to increased mortality, unnecessary expenses and the wastage of materials. False treatments and the lack of

effective screening programs are substantial reason why most cases of cervical cancer in LMIC countries reach stage III and above, usually resulting in death (Denny et al., 2017).

While most current research involves modifying the screening process to catch the disease early, relatively little is concerned with the advanced treatment process itself. Currently, there does not yet exist a cheap and accurate technology to determine a woman's cervix type, thus allowing physicians to decide on the appropriate treatment ("Intel & MobileODT," 2017). Creating this type of product will limit ineffective and costly treatments, while also improving the cervical cancer mortality rate in LMIC countries. Therefore, my goal is to create and train a features identification algorithm that will accurately identify a woman's cervix type (1, 2, or 3) based on a given image. The three cervix types are indicated below.



The imaging technology will be able to identify the stage of the cancer based on its transformation zone location, resulting in higher success prescribing treatment. This cheap and reliable application can become an invaluable asset in the cervical cancer toolkit for healthcare providers in less developed regions of the world.

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