8.1 Introduction

This chapter summarizes the findings made in this research from review of literature, during data collection and the study of the area of research. On the basis of these findings, various suggestions have been made to improve the conventional screening procedure of cervical cancer by using artificial intelligence based techniques. The necessity for adopting proposed system for cervical cancer screening and scope for further research has also been discussed.

8.2 Findings

I. The burden of cervical cancer in India is enormous accounting to about 20 per cent of all cancer related deaths in women and is the number one cause of death in middle aged Indian women. It is paradoxical that so many deaths are occurring in spite of the fact that cervical cancer is a preventable disease. Organized population based screening linked to treatment of the detected neoplasia can lead to more than 80% reduction of disease related mortality. Unfortunately, cervical cancer control is not yet among the top ten National health priorities in India. As a result, a comprehensive National Health Strategy for cervical cancer prevention is still lacking. The Pap-smear test needs a well developed laboratory based infrastructure which is usually not available in the primary health care centers in India.

II. The training requirements for proper conduct of Pap-smears is intensive and trained cyto-pathologists are largely unavailable. The cost of this test is high and is unaffordable for a nationwide program. Certain logistic issues like transporting the smears from the screening center to the laboratory, delivering the reports and recalling the test-positive women for further management are hard to implement. The sensitivity of conventional Pap smear when objectively evaluated by a multi-centric trial in different institutions in India was found to be moderate to poor. The quality control needs for a cytology based screening program are very stringent and difficult to put into practice in a country with a large population.
III. There is an absence of organized screening programs, and routine annual or bi-
annual screening of asymptomatic women in India and other developing
countries. In the public sector, the facilities for Pap smears are mostly limited to
the tertiary care centers where the test is usually offered to women with symptoms
of reproductive tract infections or advanced stage cervical cancer.

IV. Most of the institutions performing Pap smears do not have facilities for
colposcopy or treatment of cervical pre-cancer. Management of abnormal Pap
smear is either ‘follow-up’ or ‘hysterectomy’. So the low intensity, opportunistic
screening without any linkage with diagnostic/treatment services and without any
quality control mechanism is totally feeble.

V. The awareness about cervical cancer and its prevention, among educated as well
as illiterate population, is extremely poor. As a result there is no demand to
government authorities from public (who are the potential beneficiaries), to
provide routine cervical cancer screening service. The public health authorities
and the health policy-makers are not adequately sensitized to the need and are not
aware of the recent technological developments in the domain of cervical cancer
screening.

VI. There is lack of awareness about the cervical cancer in the masses, as in many
states and cities, cervical cancer is considered as a taboo due to social stigmas of
sexual transmission attached to it. As a result most women are reluctant to go
even for a preventive checkup. Many of the patients are illiterate and are often
from a rural habitation and background. Patients are from diverse socio-economic
and socio-cultural background. Many times, these patients have different beliefs
with regard to the causation, treatment and cure of disease. This causes the
condition to be worse as usually people turn up for treatment when the cancer is
in advanced stages.

VII. Detecting cervical cancer at an early stage is of prime importance as it gives a
greater chance of quicker recovery and cure. A Pap smear test done at regular
intervals supported by a schedule of follow-ups is useful in detecting any pre-
cancerous or potentially pre-cancerous changes in the body that may turn into cancer. Detecting these abnormal cells early with a Pap smear is the first step in halting the possible development of cervical cancer. As such there is a pressing need of devising strategies for regular screening and follow-up of women especially in reproductive ages.

VII. Use of latest technologies including artificial intelligence based prognostic tools/expert systems for screening of cervical cancer are almost nonexistent.

8.3 Recommendations

I. As there is lack of awareness among the people about the cervical cancer, large level public awareness programs must be introduced so as to make people aware about the seriousness of this disease and to remove the stigma associated with it. The male partner and the male elders in the family need to be made aware about women health care issues. A high level of gynecological morbidity in rural women in India has been documented, where it was observed that 92% of women had at least one disease of the reproductive tract. Hence the involvement of men is important to facilitate the timely treatment.

II. Workshops, seminars, conferences must be conducted to make women aware of different signs and symptoms that mark the onset of pre-cancerous changes, so that a swift action can be taken, if any such symptoms are observed.

III. There is a need of the political-will, with support and funding from the Ministry of Health. Screening has to be based on an adequate health infrastructure. There must be a defined target population, and means to identify, invite, screen and follow-up that population. The women in this population will have to be educated about screening for cervical cancer, and the health professionals who serve them also need to be sensitized about the latest technological developments and intelligent diagnostic tools that can assist them to reach at a precise diagnosis.
IV. Instead of using only traditional and conventional screening procedures for screening of cervical cancer, artificial intelligence based techniques should also be introduced in for initial mass level screening. Any abnormality, if detected during the initial level of screening, the case should be shifted to medical experts. There is an imperative need to introduce new modern and intelligent ways for facilitating timely detection of pre-cancerous changes.

V. A defined referral system for women with an abnormality and a mechanism to ensure women with an abnormality attend for diagnosis and treatment must be put in place. Systems to manage, monitor and evaluate the abnormalities and follow-up those treated - is also required.

VI. The facilities to enhance the accessibility for modern screening procedures to the people living in rural and remote areas must be made.

VII. As there is a dearth of training pathologists and cyto-technicians especially in far-flung areas, intelligent automated/ semi-automated methodology must be evolved and adopted for filling the gap in regular mass level screening programs.

VIII. Efforts should be made to utilize the limited resources in such a way that women who have never been screened are screened first rather than repeated screening. In large population countries like ours ‘once in a lifetime’ screening approach could form an important strategy for making the limited resources available to all.

IX. Combining artificial intelligence based techniques with conventional screening procedures can be a potential aid in lowering down the incidence of cervical cancer and the related mortality rate. Cervical Smear Analyzer proposed in this thesis is one such tool which has been built in such a way that not only a trained pathologist but also a trained cyto-technician can also use it for performing preliminary screening. These intelligent tools can prove to be a cost effective solution to the mass level screening problem of cervical cancer and thus can help in mitigating the financial burden of cervical cancer over the nation.
X. Research and development should be encouraged for designing more intelligent tools that can assist medical experts in achieving timely and precise diagnosing of other diseases as well.

8.4 Scope of further research

I. This study can be extended to other diseases as well. For such extension, relevant factors need to be identified after detailed study of concerned literature and consultation with medical experts.

II. The study reported in this thesis can be further improved by enriching the database used for training of proposed Hierarchical modular artificial neural network, to including more number of clinical cases so that the database becomes more diverse.

III. The work presented in this thesis is limited to cytological features of cervical cells, however if some genetic features are also incorporated in the study, the overall results can become more robust.

IV. The Hierarchical modular artificial neural network proposed in this work can be embedded into a hardware device to makeup a portable cervical cancer screening tool.