Investigating the Effects of Environmental Factors on the Detection of Laryngeal Cancer from Speech Signals Using Machine Learning.

Approximately 2000 people in the UK are diagnosed with laryngeal cancer each year [1]. When a patient presents to their primary care provider with symptoms indicating that they may have laryngeal cancer (for example: a change in voice, pain or difficulty swallowing, or a lump/swelling in the neck), they are referred on the two week wait pathway (2WW) [1], [2]. The 2WW pathway ensures patients are seen by a specialist in secondary care within two weeks of their referral from primary care. Only approximately 4.3-8.0% of patients referred on the 2WW pathway are diagnosed with head and neck cancer [3]. The large proportion of patients referred on this pathway who do not have a head and neck cancer increase the burden on the specialists and use of healthcare resources. Since one of the initial symptoms of laryngeal cancer is a change in voice, we believe that an artificial intelligence (AI) tool may be able to detect laryngeal cancer from features of speech. Such a tool would provide a non-invasive test that could be used for the prioritisation and screening of patients within the patient's home without the use of specialist equipment. Figure 1 shows how an AI system may be used to change the current diagnosis pipeline in the UK. The proposed AI system will allow for the classification and prioritisation of high-risk patients to specialists and ensure more appropriate allocation of resources.

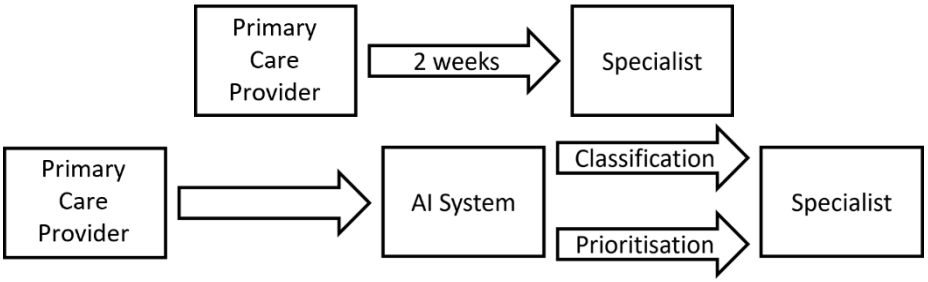

Figure 1 – The current diagnostic pipeline for head and neck cancer in the UK (top). The proposed diagnostics pipeline including the AI system for classification and prioritisation (bottom).

Related work in this field has used artificial intelligence and machine learning methods to differentiate healthy controls from patients with vocal pathologies using a range of methods [4]. Although the classifiers presented often perform well on the provided dataset the conditions in which the dataset is collected are usually very controlled. When creating such a system for use by the public outside of controlled environments it's important to understand how environmental variations can affect performance. In early work we have found that the addition of background noise to speech signals increases the incidence of false positive results when detecting throat cancer patients from healthy controls. A support vector machine (SVM) and a convolutional neural network (CNN) were trained on clean speech signals to classify cancer patients from healthy controls. Both of these classifiers were then tested on both clean and noisy signals. The precision of both classifiers decreased when tested on the noisy signals, from 80% to 65% for the SVM and from 83% to 62% for the CNN. If the systems implemented are not robust against environmental conditions it will not relieve the burden on healthcare systems, and may, in fact, increase this burden. In future work we plan to create an AI system that will be robust to environmental factors (such as background noise) such that the system will be usable by patients non specialist recording environments.

[1] NHS, 'Laryngeal (larynx) cancer', *nhs.uk*, Jun. 07, 2018. https://www.nhs.uk/conditions/laryngeal-cancer/ (accessed Aug. 23, 2021).
[2] L. Elliss-Brookes *et al.*, 'Routes to diagnosis for cancer – determining the patient journey using multiple routine data sets', *Br J Cancer*, vol. 107, no. 8, pp. 1220–1226, Oct. 2012, doi: 10.1038/bjc.2012.408.
[3] T. Tikka *et al.*, 'Head and neck cancer risk calculator (HaNC-RC)—V.2. Adjustments and addition of symptoms and social history factors', *Clin Otolaryngol*, vol. 45, no. 3, pp. 380–388, May 2020, doi: 10.1111/coa.13511.
[4] H. Kim *et al.*, 'Convolutional Neural Network Classifies Pathological Voice Change in Laryngeal Cancer with High Accuracy', *Journal of Clinical Medicine*, vol. 9, no. 11, Art. no. 11, Nov. 2020, doi: 10.3390/jcm9113415.