Enhanced Efficiency and Reduced Emissions by Optimizing Breast Cancer Survivor Follow-ups

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Introduction

Cancer patients rely not just on specialist care but also primary care services for medication and symptom management. A shared care network of Survivor Clinics comprising 14 GPs and 9 SingHealth Polyclinics (***Fig. 1***) was thus established in 2023 to improve care accessibility. While it is expected that access to community-based tertiary care will reduce the burden of travel on patients and its corresponding environmental impact, there exists little research in Singapore to lend empirical support to this assumption.

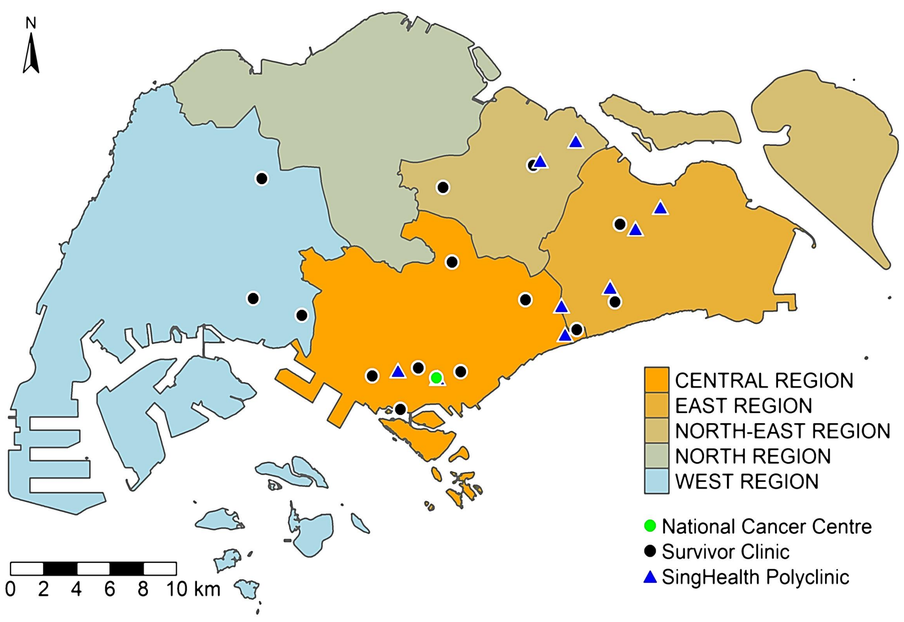

Figure 1: Locations of Survivor Clinics

Objectives

This study aims to evaluate the extent to which siting patients at the nearest survivor clinic in the shared care network reduces patients' treatment burden and contributes to healthcare decarbonisation.

Outcomes examined include travel time and distance saved and avoided emissions of greenhouse gases like carbon dioxide (CO_2), carbon monoxide (CO), volatile organic compounds (VOC), and nitrogen oxides (NO_x).

Methods

This is a retrospective, cross-sectional study that uses deidentified data of eligible NCCS breast cancer patients who enrolled in the survivorship programme from 1st March 2023 to 1st March 2024. Data processing and geo-analysis were conducted using R and Python. The 'OneMap' API, developed by the Singapore Land Authority, facilitated the conversion of patients' residential postal codes and survivor clinics to latitude and longitude values. Patients were then matched to the nearest survivor clinic based on the shortest Euclidean distance. The R package gmapdistance was used in conjunction with the Google Maps Distance Matrix API ("**GMDM API**") to estimate the time and distance travelled for a return-trip between the healthcare facility and the patient's place of residence.

Avoidable CO_2 emissions were calculated with reference to the travel distance saved by redirecting patients to the nearest survivor clinics, compared to continued visits to NCCS. All journeys were assumed to be made using a passenger vehicle with an emission factor of 0.170 kg/km (***Ref. 2***), using the formula in ***Eqn (1),*** where $\mathbf{D}$ represents the distance travelled per trip (in km), $\mathbf{N_1}$ the number of patients, $\mathbf{N_2}$ the number of trips a patient made per year, $\mathbf{F}$ the emission conversion factor (in kg/km).

GHG emission per year = $\mathbf{D} * \mathbf{2} * \mathbf{N_1} * \mathbf{N_2} * \mathbf{F}$ **(1)**

Results

Our cohort of 420 patients has a median age of 53 years (IQR=47-62 years). Siting follow-ups at the nearest Survivor Clinic would save these patients 43.6 minutes on average and reduce mean distance travelled by 22.2 km per patient (***Fig. 2***). This yields an overall annual saving of 305 hours and 9,324 km of travel for the cohort, representing a substantial 46% reduction in travel time and a 75% decrease in distance travelled.

Savings in distance travelled, in turn, correspond to 15,851 kg of CO_2, 540 kg of CO, 60 kg of VOC, and 40 kg of NOx in avoided emissions over a 10-year period (***Fig. 3***). Assuming a CO_2 sequestration rate of 21.77 kg per year per tree, the avoided CO_2 emissions for this cohort of 420 patients is equivalent to that offset by 728 trees.

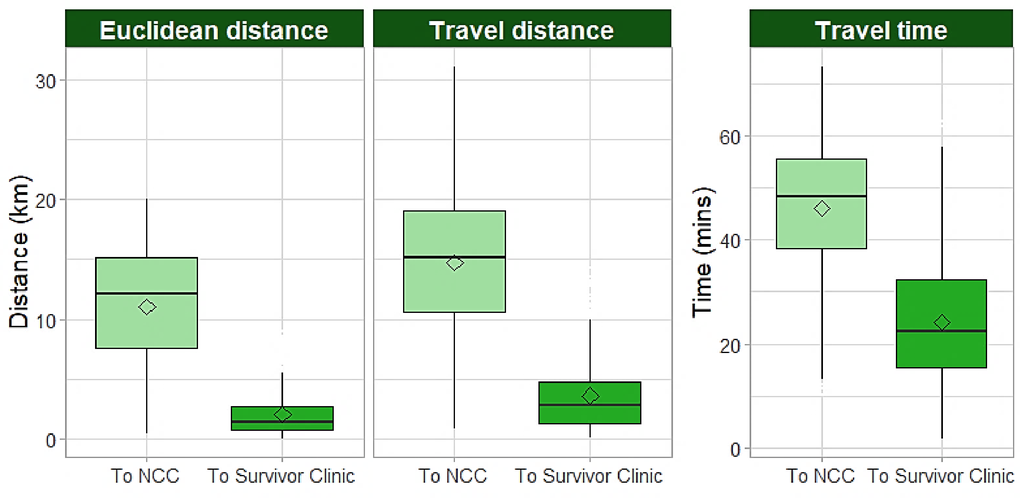

Figure 2: Boxplot of time and distance travelled per patient per trip

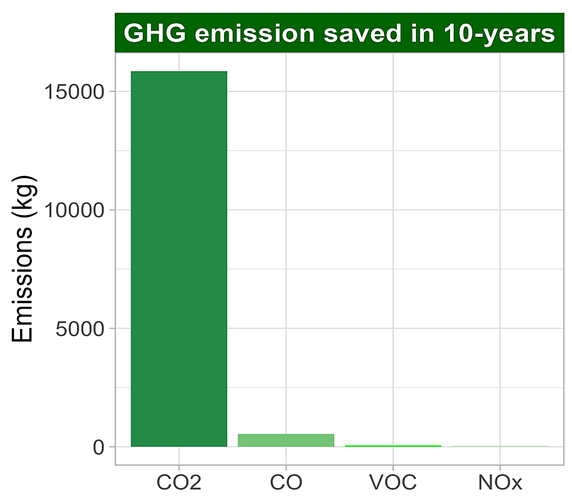

Figure 3: Barplot of GHG emission saved

While the volume of CO, VOC, and NOx avoided emissions pale in comparison to that of CO_2, it is worth noting that these atmospheric pollutants pose significant harms to human health. Volatile organic compounds (VOCs), for instance, contribute to the formation of ground-level ozone and smog, which increase the risk of lung infections. Certain VOCs like benzene are also known carcinogens, underscoring the public health co-benefits of decarbonisation initiatives.

Conclusion

Redirecting patients to the nearest primary care facility in a shared care network will net time and emission savings that benefit patients and the wider community. Scaling up this model of care to include other patient populations may help relieve the pressure on specialist elective care, improve access to timely and coordinated care, and reduce the carbon-intensity of healthcare service delivery. Looking ahead, the study team seeks to fine-tune the study's parameters by examining the mode of transport used by patients and extend the analysis to include telemedicine, which circumvents the need for patient travel altogether.

References

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2. UK Greenhouse Gas Reporting: conversion factors 2022.
3. Krupal B. & Patel et al., Estimated carbon emissions savings with shifts from In person visits to telemedicine for patients with cancer, 2023.
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