Life-cycle CO2 and Cost Reduction Potential through Operational Efficiency Improvements via Data Envelopment Analysis in the Japanâ€™s medical sector

Topic: Sustainable Production and Consumption Policies
Author: Daigo Ushijima
Co-Authors: Haruka Mitoma, Tomoaki Nakaishi, Shigemi KAGAWA

In 2021, the Japanese population aged 65 reached 36 million, constituting 29% of the total population. Moreover, the number of Japanese individuals aged 65 years and above is projected to continuously rise, with the proportion of older adults expected to reach 35% by 2040. Consequently, there will be an increased demand for healthcare services catering to older adults. Modern medical services rely on diagnostic imaging equipment for disease detection and post-treatment observation, with general clinical imaging devices providing swift and accessible physical information. Specifically, Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) offer detailed cross-sectional images of the human body.

The number of CT units In Japan were 6.8K in 1990 and 20.2K in 2020, while the number of MRI units was 756 in 1990 and 7.2K in 2020. This signifies a remarkable increase of 114% for CT and 860% for MRI over the past 30 years. Considering the advancing aging society in Japan, the introduction of CT and MRI units in hospitals and clinics is expected to continue growing. However, there is substantial variation in the number of CTs and MRIs per population across prefectures, with a negative correlation observed between the number of examinations per unit and the number of CTs and MRIs per population. This suggests inefficient operation of CTs and MRIs on a national scale, and there may also be variations in operational efficiency at the prefectural level. Inefficient use of medical devices could lead to excessive lifecycle CO2 emissions.

In 2011, CO2 emissions from the Japanese healthcare sector amounted to 62.5Mt-CO2, and these emissions increased by 16% between 2011 and 2015. CO2 emissions from the healthcare sector in 2015 constituted 5.4% of Japanâ€™s total CO2 emissions, equivalent to the direct CO2 emissions from the private car sector (Nansai et al., 2020). To reduce the carbon footprint of healthcare services, efficient utilization of medical devices is crucial. To the best of our knowledge, this study is the first attempt to assess the operational efficiencies of CT and MRI in each of the 47 prefectures in Japan using Data Envelopment Analysis (DEA) and to estimate the potential reduction in CO2 emissions and costs by minimizing unnecessary CT and MRI usage in each province.

The empirical results based on a comprehensive hospital database covering 47 prefectures of Japan show that the average operational efficiencies of CT and MRI nationwide were 0.72 and 0.77, respectively. Furthermore, the eastern regions of Japan exhibited higher operational efficiency scores, while lower scores were predominant in the Kyushu and Shikoku regions, highlighting a substantial efficiency gap in Japanese hospitals. The DEA scores estimated a total reduction potential of 3,410 units (23% of the total) for CT and 1,215 units (17% of the total) for MRI in Japan.

The combined reduction potential for equipment- and electricity-derived CO2 from minimizing unnecessary CT and MRI usage in Japan was 545 kt-CO2, constituting approximately 1% of the medical sector's life-cycle CO2 emissions in the country. Notably, a significant percentage of Japanese hospitals expressed limited interest in future energy reduction opportunities. Despite the government's emission intensity target of a 1.57% reduction, the study concludes that there is substantial potential for CO2 emission reduction through the efficient use of capital equipment in Japan's medical sector.

Furthermore, the nationwide potential for cost reduction, based on the reduction potentials of CT

and MRI, was estimated at 313 billion yen. This amount is equivalent to about 90% of the total medical deficit of all university hospitals, suggesting that inefficient equipment operation may be placing strain on hospital management.

The study highlights that the inefficient operation of medical imaging equipment, such as CT and MRI, in Japan leads to excessive environmental burden and costs. In Japan, there are no laws restricting the introduction of medical devices. Therefore, to maintain the operational efficiency of the equipment, Japan should refrain from introducing new devices. Additionally, in order to reduce environmental impact and costs, each local government should consider reallocating existing medical equipment and promote collaborative use of devices among hospitals to ensure their efficient utilization.