Estimating the Carbon Footprint Generated by Medical Students

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ABSTRACT

Introduction: A carbon footprint refers to the total amount of greenhouse gas (GHG) emissions generated by individuals, organizations, or specific activities, typically expressed in carbon dioxide equivalents (CO_2e). Healthcare, including medical education, is responsible for a considerable portion of global carbon emissions, accounting for approximately 4.4%.

Objective: To estimate the carbon footprint of medical students, according to household (occupants, electricity, natural gas, heating oil, coal, LPG, propane, and wooden pellets), transportation (flights, car, motorbike, bus & rail), and secondary (consumer goods, pharmaceuticals, technology, automotive, hospitality & leisure, and finance & insurance) emissions.

Methods: This study used descriptive design to estimate the carbon footprints of medical students as to household, transportation, and secondary emissions, wherein the data were collected quantitatively using an online carbon footprint calculator, specifically the Carbon Footprint™ calculator.

Results: Overall emissions per student average 14.228 tons, with a median of 2.390 and a very high maximum of 202.240 tons. This highlights a huge disparity within the group—suggesting the presence of a few extremely high emitters influencing the average disproportionately. The dataset underscores profound inequality in carbon footprints among medical students, mirroring broader national trends noted in the Philippines. The sharp contrast between median and maximum values across all categories suggests a heavy-tailed distribution, indicating that while most students live relatively low-carbon lifestyles, a minority significantly surpass typical emission levels, likely due to privileged access to private transportation, energy-intensive housing, or high-consumption habits.

Conclusion: Sustainable practices such as reducing the use of disposables, optimizing travel, and shifting toward virtual or hybrid academic activities can significantly cut down emissions related to transport and accommodation. Cultivating sustainable habits in future healthcare professionals is not only necessary but foundational to a greener, more responsible medical future.

Key words: carbon footprints, greenhouse gas, carbon dioxide equivalents

A carbon footprint refers to the total amount of greenhouse gas (GHG) emissions generated by individuals, organizations, or specific activities, typically expressed in carbon dioxide equivalents (CO_2e). Healthcare, including medical education, is responsible for a considerable portion of global carbon emissions, accounting for approximately 4.4% (Karliner et al., 2019). As medical education continues to evolve, a deeper understanding of its environmental impact is essential to promote sustainable practices that can mitigate the healthcare sector's overall carbon footprint. This study hypothesizes that medical students contribute to carbon emissions through their household, transportation, and secondary

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activities, with certain behaviors having the potential to significantly reduce their carbon footprint. This research is significant as it seeks to understand the environmental impact of medical students' lifestyles, offering insights into how specific changes can promote sustainability and reduce their overall carbon emissions, contributing to climate change mitigation efforts while ensuring that their education remains effective and relevant to their future roles as healthcare professionals.

The study aims to determine the carbon footprint of medical students, according to household (occupants, electricity, natural gas, heating oil, coal, LPG, propane, and wooden pellets), transportation (flights, car, motorbike, bus & rail), and secondary (consumer goods, pharmaceuticals, technology, automotive, hospitality & leisure, and finance & insurance) emissions.

MATERIALS AND METHODS

Study Design

This study used descriptive design to estimate the carbon footprints of medical students as to household, transportation, and secondary emissions. The data was collected quantitatively using an online carbon footprint calculator, specifically the Carbon Footprint™ calculator.

Study Population and Study Site

The study population consisted of currently enrolled 1st year to 3rd year medical students of Far Eastern University - Dr. Nicanor Reyes Medical Foundation (FEU-NRMF) during the academic year 2024-2025.

Eligibility Criteria

Inclusion Criteria

The study required participants to be enrolled in the Doctor of Medicine (MD) program at FEU-NRMF, specifically focusing on students in their 1st, 2nd, or 3rd year of medical education. Participants were at least 18 years of age or older.

Exclusion Criteria

Individuals who have voluntarily withdrawn or suspended their studies for any reason. Students with pre-existing chronic conditions were likewise excluded for their use of pharmaceutical products that would affect generation of carbon footprints.

Sampling Methodology

A stratified random sampling method was used to ensure a representative sample of medical students from different year levels (1st, 2nd, and 3rd year) at FEU-NRMF.

Recruitment of Participants

Participants were recruited through official school communication channels such as emails and social media platforms. Recruitment materials included information about the study's purpose, eligibility criteria, and instructions for completing the online survey. Voluntary participation was emphasized, and informed consent was obtained from all participants prior to data collection. Follow-up reminders were sent to increase response rates. The research protocol was exempted from review as per the Institutional Ethics Review Committees (IERC) of FEU-NRMF.

Data Collection

Data were collected through a google form, and the following data were inputted in the Carbon Footprint™ calculator, as suggested in the study of Murlow et al. (2018) for individual carbon footprint calculation. Participants were given access to the survey link and guided to enter specific data regarding their household, transportation, and secondary emissions. The online calculator quantifies the carbon footprint of each participant based on his/her inputs.

The study collected data across several key categories to estimate the carbon footprint generated by the activities of medical students. Household emissions include information on the number of household occupants, electricity consumption, and the use of natural gas, heating oil, coal, LPG, propane, and wooden pellets. Transportation emissions captured details on participants' use of various modes of transport, including cars, motorbikes, buses, and trains. Secondary emissions focused on consumption patterns related to goods, pharmaceuticals, technology, automotive services, hospitality and leisure, and finance and insurance. Additionally, demographic data such as age, year level, and residential setup were collected to provide context for understanding how these factors may influence the carbon footprint of the students.

Instrument

Data were collected through a google form, and the computation of data was through Carbon Footprint™ calculator. This can be used freely online and offers personalized and reliable estimates with high Feature Index scores (Murlow 2018)

Operational Definition

Carbon Footprint of Medical Students: The total amount of greenhouse gasses (GHGs), measured in metric tons of CO_2 equivalents (CO_2e), generated by the activities and consumption patterns of medical students using the Carbon Footprint™ calculator. Emissions were categorized into three main sources: household emissions, transportation emissions and secondary emissions for a comprehensive analysis of their carbon footprint. The total carbon footprint was categorized into below the country's average carbon emissions (<1.2635 metric tons), within the country's average carbon emissions (1.2635 - 1.3965 metric tons), or above the country's average carbon emissions (> 1.3965 metric tons). The total carbon footprint emissions was compared to the average footprint for people in the same region, Malaysia, that were categorized into below Malaysia's average carbon emissions (<7.22 metric tons), within Malaysia's average carbon emissions (7.22–7.98 metric tons), or above the country's average carbon emissions (> 7.98 metric tons)

Household Emissions: The GHG emissions attributed to the energy consumption within a student's residence. The total household emission (measured in metric tons) is comprised of the consumption of electricity, natural gas, heating oil, coal, LPG/propane, and wooden pellets; this is then divided into the number of occupants in each household. This is further defined as:

- *Occupants*: The number of individuals living in the household, influencing the shared use of energy resources.
- *Electricity*: Emissions generated from the consumption of electrical energy within the household, based on regional grid energy sources (renewable vs. non- renewable) and measured in Kilowatt Hour (kWh).
- *Natural Gas*: Emissions from the use of natural gas for heating, cooking, or other domestic purposes and measured in kWh or therms (100 cubic feet of natural gas/CCF).
- *Heating Oil*: Emissions from the combustion of heating oil used to heat the household and measured in kWh, liters (L), metric tons, or in US gallons.
- *Coal*: Emissions from coal use, if applicable, for heating or electricity. Measured in kWh, metric tons, or bags of coal.
- *LPG & Propane*: Emissions from liquefied petroleum gas and propane used in cooking or heating. LPG is measured in kWh, liters (L), therms, or in US gallons. Propane is measured in liters or US gallons.
- *Wooden Pellets*: Emissions from burning wood pellets as a renewable or non- renewable source of heat and measured in metric tons.

Transportation Emissions: The GHG emissions resulting from the use of various transportation modes by medical students. The total transportation emission is comprised of the sum of flight and airfare consumption, car emissions, motorbike emissions, and bus & rail emissions. These are further defined as:

- *Flights*: In this study, refers to the use of air travel by medical students as part of their transportation activities, which contribute to their overall carbon emissions. Data on flights were collected based on the following parameters:
  - *Trip type*: One-way or return flight
  - *Origin*: Name of the departure airport or city
  - *Destination*: Name of the arrival airport or city
  - *Stopover*: Indication of any stopovers or connecting flights, including the name of the stopover airport
  - *Class of service*: Economy, premium economy, business, first class, or unknown class (if not specified)
  - *Number of trips*: Total number or frequency of trips taken over a specified time period
- *Car*: In this study, "Car" refers to the use of private vehicles by medical students for transportation, contributing to their overall

carbon footprint. Data on car usage were collected using the following parameters:

- *Mileage*: Total distance traveled, measured in kilometers (km)
- *Vehicle type*: Make, model, and car type (e.g., sedan, SUV, compact, etc.)
- *Year of manufacture*: The production year of the vehicle
- *Fuel efficiency*: Fuel consumption measured in liters per 100 kilometers (L/100 km), categorized by fuel type (e.g., petrol, diesel, LPG, CNG)

- *Motorbike*: Emissions from the use of motorcycles or scooters. Measured in mileage (in km) per type of engine of the motorbike (<125 cc, 125 cc to 500 cc, or >500 cc). Alternatively, it can also be measured by fuel efficiency or the fuel consumption measured in L/100 km.
- *Bus & Rail*: Emissions from public transportation use, including buses (short distance), coach (long-distance bus), commuter trains, long-distance train, tram, subway, or taxi. Measured in km or miles traveled on average.

Secondary Emissions: In this study, "Secondary emissions" refer to the indirect greenhouse gas emissions resulting from the consumption of goods and services by medical students. These emissions are associated with the production, transportation, and disposal of various products and services, contributing to the overall carbon footprint. The total secondary emission is comprised of the sum of emissions from food and drink products, pharmaceuticals, apparel, paper-based products, computers and IT equipment; television, radio, and phone equipment; motor vehicles; furniture and other manufactured goods; hotels, restaurants, pubs, and similar establishments; telephone/mobile call costs; banking and finance; insurance; education; and recreational, cultural, and sporting activities. Data on secondary emissions were collected based on the following categories:

Food and Drink Products: Average food and beverage consumption of medical students. This includes variables including:

- *Diet classification* based on animal product consumption: heavy meat eater, medium meat eater, low meat eater, pescatarian, vegetarian, vegan.
- *Spending*: Measured in Philippine pesos (PHP) over a range of time (weekly, monthly, or yearly).

Other consumption categories: Secondary emissions in carbon footprints refer to the indirect greenhouse gas emissions associated with the production, distribution, and disposal of goods and services consumed by individuals or organizations. These emissions are measured in terms of PHP spent over various timeframes (weekly, monthly, or yearly) dependent on the respondents across different consumption categories. Key categories include pharmaceuticals; clothes, textiles, and shoes; and paper-based products such as books, magazines, and newspapers. Technology-related items like computers, IT equipment, and television, radio, and phone equipment also contribute to secondary emissions. Other categories encompass motor vehicles (excluding fuel costs), furniture, and other manufactured goods. The hospitality sector, including hotels, restaurants, and pubs, along with telecommunications (e.g., telephone and mobile call costs), banking and finance (such as mortgage and loan interest payments), and insurance, are additional contributors. Education and activities related to recreation, culture, and sports further highlight the diverse sources of secondary emissions tied to everyday consumption.

Sample Size Calculation

Sample size was calculated based on the estimation of the population proportion of students expected to have within average carbon footprint sent at a conservative estimate of 50% with a maximum allowable error of 5% and a reliability of 80-95% sample size required is 165.

Data Management and Analysis

The quantitative data collected from surveys was organized and analyzed using Google Sheets. Descriptive statistics were conducted in order to better understand the distribution of carbon footprint across different categories.

RESULTS AND DISCUSSION

The data in table 1 reveal that medical students exhibit a wide disparity in their carbon emissions across different consumption categories. Household emissions, with a mean of 0.436 tons and a relatively high standard deviation (SD) of 2.305, show that while the majority contribute minimally (median of 0.100), a few individuals account for much higher levels (maximum of 29.080 tons). This skewed distribution suggests that certain lifestyles or living conditions drastically amplify household emissions among students.

Transportation emissions are notably the largest single contributor among the categories, with a mean of 4.731 tons and maximum reaching 201.240 tons, indicating significant variation. The median (0.200) remains low, reinforcing that while most students have modest transport-related emissions, a few outliers— likely due to frequent long-distance travel or personal vehicle use— dramatically inflate the average.

Secondary emissions, which likely include indirect emissions from goods and services consumed, show a mean of 9.027 tons, also skewed with a high SD of 22.345. This suggests substantial variation in consumption habits, potentially influenced by socio-economic status or academic demands.

Medical education mirrors this high-emission profile through students' reliance on travel, energy-intensive facilities, and disposable medical supplies (Health Care Without Harm, 2019). The data showing elevated student emissions—especially in transportation and secondary categories—highlight the indirect environmental costs of medical training. This aligns with prior research emphasizing the role of medical students in perpetuating the sector's carbon intensity through energy-dependent practices and travel habits (Sharma et al., 2023).

Overall emissions per student average 14.228 tons, with a median of 2.390 and a very high maximum of 202.240 tons. This highlights a huge disparity within the group—suggesting the presence of a few extremely high emitters influencing the average disproportionately.

The dataset underscores profound inequality in carbon footprints among medical students, mirroring broader national trends noted in the Philippines. The sharp contrast between median and maximum values across all categories suggests a heavy-tailed distribution, indicating that while most students live relatively low-carbon lifestyles, a minority significantly surpass typical emission levels, likely due to privileged access to private transportation, energy-intensive housing, or high-consumption habits.

These disparities are particularly critical in understanding student lifestyles and their potential role in emission inequality. Much like the national data on household emissions across income deciles, this student-specific analysis suggests that emissions scale disproportionately with affluence— those with more resources or higher consumption capabilities contribute disproportionately to carbon output. This has meaningful implications for university-level sustainability initiatives, which may benefit from targeted interventions—such as incentivizing low-carbon commuting or reducing indirect emissions through campus services.

Moreover, the prominence of secondary and transportation emissions signals that strategies aimed solely at direct household consumption may overlook more substantial contributors. For effective reduction of student carbon footprints, policy and behavior change should focus on travel behavior, consumption patterns, and systemic access to lower-carbon options.

The data presented in Table 2 offer a comparative analysis of medical students' total estimated carbon footprints against national average ranges for the Philippines and Malaysia. A substantial majority of students (71.95%) record above-average emissions compared to the Philippine national average (1.2635–1.3965 metric tons). This figure sharply contrasts with only 25.46% of students exceeding Malaysia's significantly higher average range (7.22–7.98 metric tons). Conversely, only 26.83% of the students fall below the Philippine average, while a dominant 73.94% fall below Malaysia's average, highlighting

Table 1. Estimated carbon footprint in each category.

	Minimum	Median	Maximum	Mean	SD
Household Emissions	0.000	0.100	29.080	0.436	2.305
Transportation Emissions	0.000	0.200	201.240	4.731	18.381
Secondary Emissions	0.000	1.350	156.690	9.027	22.345
Overall Emissions	0.010	2.390	202.240	14.228	29.643

Table 2. Total estimated carbon footprint and its categorization in comparison to the average range of carbon footprint emission in the Philippines & Malaysia.

Category (Overall)	Philippine Emissions				Malaysian Emissions			
			Mid-P exact				Mid-P exact	
	F	%	Lower CL	Upper CL	f	%	Lower CL	Upper CL
*Below average**	44	26.829	23.100	37.000	122	73.939	66.840	80.210
Within average	3	1.829	0.465	4.867	1	0.606	0.030	2.952
*Above average***	118	71.951	51.770	66.690	42	25.455	19.250	32.510

****Below**: Pertains to participants with emission values **below** the average range (Philippines = 1.2635 - 1.3965 metric tons; Malaysia = 7.22 - 7.98) for each category.*

*****Above**: Pertains to participants with emission values **above** the average range (Philippines = 1.2635 - 1.3965 metric tons; Malaysia = 7.22 - 7.98) for each category.*

that although many students surpass the Philippine norm, their emissions still generally fall short of Malaysia's national profile.

The Mid-P exact confidence intervals reinforce the reliability of these proportions. For instance, the confidence interval for Philippine "above average" emissions lies between 51.77% and 66.69%, affirming a significant overrepresentation. Similarly, the Malaysian "below average" category has a strong confidence range between 66.84% and 80.21%, indicating consistent underrepresentation in higher emissions within that context.

This comparison to Malaysia serves a valuable analytical purpose. Malaysia is a geographically proximate Southeast Asian country, sharing certain developmental, climatic, and urban-rural characteristics with the Philippines. Both countries have comparable land areas, are classified as developing economies, and face similar pressures related to urbanization, energy transition, and household consumption patterns (Andaya, 2023; Leinbach, & Frederick, 2025). By juxtaposing Philippine emissions against Malaysia's, the study introduces a regional benchmark that situates the carbon footprint of Filipino medical students not only within a national but also within a broader ASEAN context. Malaysia's higher national average also provides a useful upper boundary for understanding what more carbon-intensive lifestyles in the region might look like, offering insight into future trajectories if Filipino consumption patterns shift similarly.

This comparison strengthens the case for targeted sustainability measures, revealing that while Filipino students exceed domestic norms, they remain well below regional high-emission scenarios. It urges proactive planning to prevent potential escalation in emissions as access to resources, mobility, and consumer choices expand.

CONCLUSION AND RECOMMENDATION

The findings of this study reveal substantial disparities in the carbon footprints of medical students, particularly in transportation and secondary emissions, with overall averages notably exceeding the Philippine national range. This underscores the importance of integrating sustainability into both medical curricula and practice to foster environmentally conscious healthcare professionals. Efforts to reduce the environmental impact of medical education include promoting sustainable practices such as minimizing waste from disposable medical supplies and implementing energy-saving measures within academic institutions. Sustainable practices such as reducing the use of disposables, optimizing travel, and shifting toward virtual or hybrid academic activities can significantly cut down emissions related to transport and accommodation. Cultivating sustainable habits in future healthcare professionals is not only necessary but foundational to a greener, more responsible medical future.

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