- *Basic Research*

Carbon Footprint' Knowledge and Calculation among Nursing Students

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Abstract

Background: Nursing students as future health leaders to advocate for a greener planet, have a significant responsibility in mitigating climate change and reducing humanity' carbon footprint (CF). While the CF per capita among nursing students is unknown, and whether they are well knowledgeable about effective measures for reducing CF.
Aim: Assess carbon footprint knowledge and calculation among nursing students
Methodology: A descriptive-analytic research design was applied for A stratified simple random sample to 279 nursing students from the faculty of nursing, at Modern University for technology and information. ***Two tools were used:*** (1) Nursing Faculty Students' Structured Questionnaire which consisted of two sections to assess the demographic characteristics of the students and their families. Additionally assess students' knowledge about CF. (2) Carbon Footprint Calculator.
Results: 67.38% of students had a poor level of CF knowledge. The total mean CF of the nursing students was 5.874±0.182 mtCO2/year. Many demographic variables of the students and their families were associated statistically with the average students' CF; gender, living alone, parents' educational level, mother's occupation, income, and place of residence. Statistically, significant inverse correlations were found between the students' CF knowledge with their average CF per capita.
Conclusions: The majority of the nursing students had poor knowledge of CF, Additionally, the average CF per capita among nursing students was higher than the average CF worldwide and two-fold higher than Egypt's CO2 emission per capita.
Recommendations: Updating the universities nursing curriculum with the environmental global issues, with a deeper focus on nurses' responsibility toward innovative strategies to lower CF.

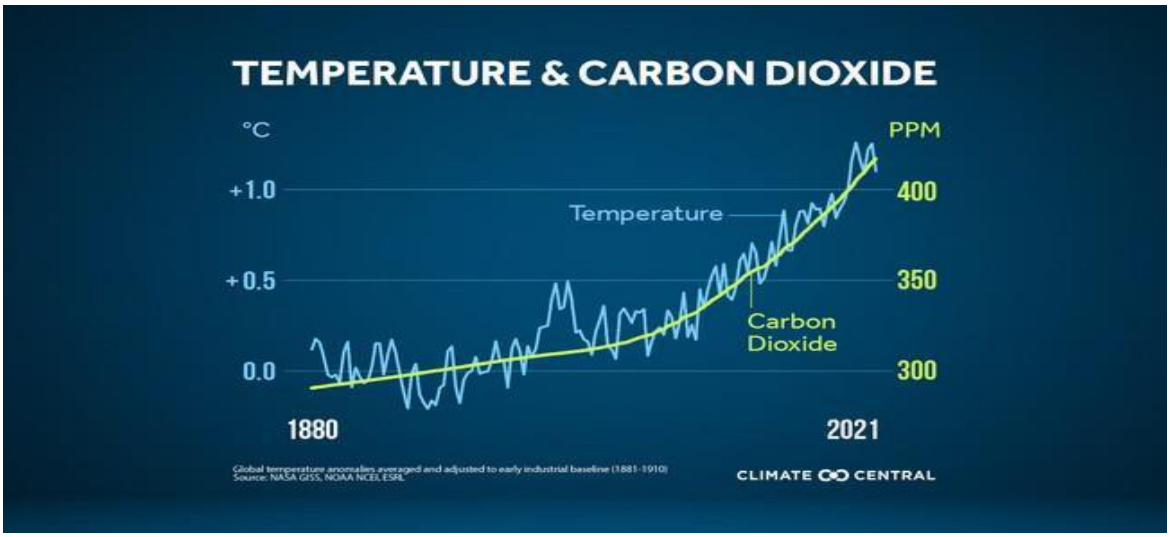
Keywords: Nursing students, Carbon footprint, Climate change

1. Introduction:

Climate change has become the biggest threat to public health in the 21st century, so carbon footprint (CF) calculations have become highly demanded [1]. CF is a professional term that has frequently been used not only among meteorologists but also among ordinary people in public debates to combat the threat posed by climate change. "CF is generally recognized as an indicator to quantify total greenhouse gas (GHG) emissions by a person, an organization, an event, or a product, in terms of CO2 equivalents (CO2-eq) for a period of one year [2].

Carbon dioxide (CO2) emissions are a significant leading cause of climate change [1]. The energy consumption continues to rise, so CO2 emission continues to rise with it. In the year 1950, and for the first time in human history, the average atmospheric CO2 level exceeded more than 300 ppm (parts per million). While in 2020, reached 412.5 ppm, and is still increasing at an annual rate over 100 times faster than the previous natural increase over the past 60 years [3]. CO2 traps heat from the sun's radiation in the atmosphere, resulting in rising temperatures of the planet's surface (phenomena of global warming) and climate change [4]. In 2020, the global mean temperature was increased by 2.29 Fahrenheit (1.27 Celsius) above the average temperature of the late 19th century in pre-industrial times [5], and it is expected to rise to 5.4°C by 2100 [6]. The graph below illustrates how the average global temperature increased from the years of 1880 to 2021 based on the amount of extra CO2 pumped into the atmosphere, **Figure (1)**.

Figure (1)



Atmospheric CO2 concentration and global temperature curves - Climate Central
***Source**: Chief Meteorologist Steve LaPointe (2022): Soaring CO2 Raising Global Temperatures, Another Record Set This Year (2022). https://cbs6albany.com/weather/weather-extra/soaring-co2-raising-global-temperatures-another-record-set-this-year-2022.*

According to Intergovernmental Panel on Climate Change report **(IPCC 2013)** [7], anthropogenic (human) activity is the most predominant contributor to the remarkable warming and climate change since the mid-20th century (industrial revolution) as a result of GHG emissions. CO2 is the most influential of Earth's long-lasting GHG and accounts for more than three-quarters of anthropogenic GHG emissions [8]. Some of these anthropogenic activities are primarily presented in fossil fuels burning (coal, natural gas, and oil), deforestation or intensive agriculture, livestock farming, industrialization, and electricity. Furthermore, buying food and goods would also contribute to global warming [9]. A higher elevation of CO2 emissions is mainly expected in heavily urbanized areas with dense populations where heavy industry, power plants, heavy road transport, heating, respiration, and waste degeneration [10].

In this perspective, CF calculates the total CO2 emissions directly and indirectly caused by human activities or through the life cycle of products due to individuals' consumption of energy, food, clothing, housing, or activities carried out daily. Various websites carbon calculators are freely available (for example; CoolClimate Calculator, WWF Footprint Calculator, CarbonFootprint.com Carbon Calculator, Conservation International Carbon Footprint Calculator, UN Carbon Footprint Calculator, EPA Carbon Footprint Calculator), helping to educate about the impacts of daily habits and lifestyle choices on GHG emissions. CF calculates CO2 emissions from different sectors utilized by individuals, including households, transportation, and lifestyle. Sadly, it was estimated that humanity's carbon footprint has increased 11-fold since 1961[11& 12].

Considering the environment is a major determinative of human health and the interconnection of planetary health and public health, global climate change has serious significant adverse impacts on human health worldwide, especially in African countries. The increment of atmospheric CO2 concentrations is associated with infectious and non-infectious diseases, disability, depletion of nutrition, water security, and other social disruptions. Also, increased heat exposure is associated with increased morbidity and mortality; such as heatstroke, behavioral changes, decreased work performance, respiratory failure, myocardial infarction, stroke, and death. Thus, the extreme higher risks could lead to dangerous and probably catastrophic changes in the global environment [6&13].

In this context, reducing carbon emissions and accordingly, humanity's CF is a major step to end climate overshoot and living within the means of our planet. Noteworthy, the United Nations (2015) sustainable development goals (SDGs) Goal 13 claims for global efforts to mitigate climate change as an emergency health crisis [14]. In addition, the fundamental step toward the achievement of the Paris agreement goals (2015) for reaching atmospheric net-zero carbon by the second half of this century (in 2100) would be by keeping the rise of global temperature below 2 degrees Celsius above pre-industrial levels,

in response to the mitigation of human CO2 emissions [5 & 11].

The healthcare sector has a clear mission to achieve the United Nations SDGs. Among these goals, Goal 3 is to ensure healthy lives and promote well-being for all of all ages [15]. Despite that, it has been found that healthcare professionals bear elevated CF, where healthcare produces a considerable amount of human-induced greenhouse gases, causing further climate change. Internationally, 4.4% of the world's total climatic footprint comes from healthcare [16]. Nurses are most often serving on the front lines of healthcare through active participation in public health initiatives to reduce climate change, taking early initiation, and enthusiastically advocating action for CF reduction [14]. Nurses can also teach individuals about ecologically beneficial habits, including turning off lights when not in use, switching to renewable energy sources, eating a mostly vegetarian diet, and recycling resources. Also, raise awareness about the safest methods for trash disposal, rather than just burning it [17]. Additionally, the International Council of Nurses (ICN, 2018) [18], elaborated that the concept of sustainability, climate change-and CF reduction-related knowledge must be included in nursing education, in both theoretical and practical courses, to enable nurses to act as leaders and take action to build climate-safe health systems. Thus, nursing students must be well-educated, skilled, and prepared for a professional role that can contribute to climate- and environment-friendly care [19].

2. Significance of the study:

Egypt’s national GHG, or carbon emissions profile, is broadly similar to those of its neighbors. With an estimated total emission of around 269.5 million metric tonnes of CO2e (carbon equivalent) in 2020, Egypt is among the highest in total emissions. Predictions are for Egypt’s emissions to increase at a faster pace than population growth; by the year 2030, the total emissions will have more than doubled, and Egypt’s share of world emissions will grow by 50% [20].

A progressive change in nursing higher education requires environmental sustainability competencies to be included in education curricula across all educational levels. Since University education is a good starting point for preparing nursing students, there is a high need to equip the current and next generation of nurses with the related core competencies to face the adverse effects of climate change and contribute to innovative strategies to lower CF [19]. Additionally, calculating CF of an educational institute can induce a sense of obligation among students to minimize it [21].

However, research studies about CF among university nursing students are very limited, and this study is among the first initiative studies aimed at calculating CF per capita among nursing students, as it is a major factor contributing to climate change. While knowledge is

a key driver of global actions on climate change, in this regard, evaluation of nursing students regarding their CF level and knowledge about climate change and methods to reduce CF can be used as a guide in determining the educational needs for the nursing students that will enable future curriculum development, thus helping to prepare nursing students to perform their future role toward environmental health.

3. Aim of study:

Assess carbon footprint knowledge and calculation among nursing students

4. Objectives:

- Assess carbon footprint' knowledge among the faculty nursing students.
- Calculate carbon footprints per capita among the faculty nursing students.

5. Research questions:

- **R. Q. (1):** What is the score level of carbon footprint' knowledge among the nursing students?
- **R. Q. (2):** What is the average carbon footprint per capita among the nursing students?

6. Subjects and Methods:

6.1. Design: A descriptive, analytic research design was followed in the present study.

6.2. Research Setting:

The study was conducted at the Faculty of Nursing, Modern University for Technology and Information (FON/MTIU), Egypt. as a private University supervised by the Ministry of Higher Education. The faculty of nursing introduces one program for undergraduate students (Bachelor's Degree Program) covering six nursing departments within four levels/years through eight semesters as well as internship year.

6.3. Sample size and type:

A stratified simple random sample was used; the nursing students were stratified into four levels based on the BSN nursing program, 27.5% were selected randomly from each level to reach the final sample size that was estimated to be 279 students, using Raosoft sample size calculation soft program, from the following equation: Sample Size "n = N * [Z2 * p * (1-p)/e2] / [N – 1 + (Z2 * p * (1-p)/e2]", where, N is the population size that was 1015 students enrolled in the faculty in the academic year 2021–2022, Z2 is the critical value of the normal distribution that was 50% at α/2 (at a confidence level of 95%.), p is a sample proportion, e is margin of error 5%.

The inclusion and exclusion criteria*:* nursing students registered within the academic year of 2021–2022, while the students who were not willing to participate in the study and non-complete responses to the questionnaire were excluded.

6.4. Data Collection Tools:

Tool (1): Nursing Faculty Students' Structured Questionnaire was developed by the researchers in the both Arabic and English languages by reviewing different kinds of literatures and articles in different parts of the world, and revised according to our setting. The questionnaire consisted of two sections:

- **1st section:** concerned with demographic characteristics of the nursing students including age, gender, academic year, marital status, occupation, and grade point average. As well as families' characteristics included, age, occupation, and educational level of the parents, in addition, to socioeconomic status, presence of illness, and place of residence.
- **2nd section:** assessed the nursing students' knowledge of carbon footprint, included 41 closed questions covering the following parts; definition (6 items), the importance for measuring the size of carbon footprint (3 items), factors contributing to carbon footprints (10 items), and methods for minimizing our carbon footprint (22 items).

Rating and scoring system:

Nursing students asked to respond to the knowledge questionnaire by selecting the correct answer or determining either true or false. The responses checked with a model answer, and each correct answer graded with one point, while incorrect responses given a score of zero, so the total knowledge score ranged from zero to 41, with high mean scores indicating better knowledge. As well as, the points were summed up and converted into a percent score. Students who scored above the percent of 75.0% considered as they have good knowledge, while Average knowledge level considered if percent within 50.0% to <75.0%, or poor knowledge if less than 50.0%.

Tool (2): Online Carbon Footprint calculator was used to assess and calculate the individual carbon footprint of the participants that was calculated on the criteria of a validated online carbon footprint calculator (available at: https://www.carbonfootprint.com/calculator.aspx.)[22] The calculations typically based on annual emissions from the previous 12 months for individuals and households. Electricity conversion factor used in this study was 0.672 Kg CO2e/kwh based on the Intergovernmental Panel on Climate Change (IPCC) (IPCC special report: https://www.ipcc.ch/pdf/specialreports/sroc/Tables/t0305.pdf) cited in Egyptian study of **Madkour, 2019** [23]

The web's leading carbon footprint calculator measure the following six sectors of individual life style:

- *The first sector* concerned with household footprint calculator that included seven items about electricity, natural gas, heating oil, coal, LPG, propane and wooden pellets.
- *Second sector* regarded flights carbon footprint calculator, included three items about flight itinerary, class and number of trips as well as optional via if the flight has a stopover.
- *Third sector* concerned with car carbon footprint calculator, involved 4 items about number of mileages, type of vehicle, manufacture, model for determining type of used fuel and efficiency.
- *Fourth sector* regarded motorbike carbon footprint calculator, included 2 items about mileages, and type of vehicle for calculating efficiency
- *Fifth sector* assessed public transport carbon footprint by calculating mileage for bus, coach, local or commuter train, long distance train, tram, subway and taxi.
- *Sixth sector* aimed for secondary carbon footprint calculator, involved 14 items about the following, food and drink products, pharmaceuticals, clothes, textiles and shoes, paper based products (e.g., books, magazines, newspapers), computers and IT equipment, television, radio and phone (equipment), motor vehicles (not including fuel costs), furniture and other manufactured goods, hotels, restaurants and pubs etc., telephone, mobile/cell phone call costs, banking and finance (mortgage and loan interest payments), insurance, education and recreational, cultural and sporting activities.

Scoring system:

The summation of the total and each sector of the CF was done automatically through the web's leading carbon footprint calculator for each student. Then the CF scores for the four sectors regrading transportations routes, including flights, cars, motorbike, and public transport, were embedded and multiplied. The total CF mean score of the three main sectors of household, transportation, and secondary carbon footprints was assessed using statistical measures by entering data into SPSS.

6.5. Validity of tools:

The faculty nursing students' knowledge of the Carbon Footprint Questionnaire was first developed in English and then converted to the Arabic language for clarity and back to English for consistency by non-medical experts. Also, the carbon footprint questionnaire on the previously mentioned website was translated into the Arabic language and then, retranslated back into English by a nonmedical expert. This version was compared with the original considering conceptual and cultural parameters. The content validity of the final Arabic translated version of the two questionnaires was done by submitting the tools to five experts in the field of "community health nursing in the faculty of nursing, MTI university and Ain shams university. Additionally, expertise in the field of medical surgical nursing, at the faculty of nursing, Alexandria university, in addition to a statistician," to ensure suitability with the current study, their opinions as regards to the tool format layout,

consistency, knowledge accuracy, relevance, and competencies as well as the scoring system. The final modifications were done based on the opinions of the experts.

6.6. Reliability of tools:

The coefficient test reliability of the two questionnaires evaluated using Cronbach's alpha. The translated Arabic version of the Carbon Footprint calculator questionnaire was (α= 0.79). Carbon footprint knowledge questionnaire was (α= 0.944). As well as person correlation coefficient was (<0.000**), which showed good internal consistency and good reliability.

Pearson correlation of the (4) domains of the carbon footprint knowledge questionnaire

Domains of Carbon Footprint' Knowledge Questionnaire	Total Carbon footprint' knowledge questionnaire	
	R	P-value
Definition of carbon foot print	0.672	<0.000*
Importance for measuring the size of carbon footprint	0.752	<0.000*
Factors contributing to carbon footprints	0.751	<0.000*
Methods for minimizing our carbon footprint	0.899	<0.000*

7. A Pilot Study:

A Pilot study taken for a number of 28 students equal 10.0 % of the total study sample size that was chosen randomly and excluded from the considered sample to assess the clearness, applicability, and reliability of the study tools and estimate the approximate time needed for data collection. Accordingly, any required modifications were conducted.

8. Preparatory phase:

This phase included reviewing current and past available literature and theoretical knowledge of various aspects of the study using the different textbooks, scientific articles, the internet, periodicals, and magazines, this was necessary to help the researchers to be acquainted with the actual dimensions and magnitude of the problem area of the study in Egypt and worldwide. It also guided for development of the data collection tools.

9. Field Work:

The data collection phase began from October 2021 to the end of January 2022. The students were interviewed by the researchers in the faculty before data collection, in which the aim and purpose of the study were explained by the researchers, as well as a specific explanation of the importance of the study and how to fill in the questionnaires. Moreover, their formal approval to participate in the study was obtained. The two questionnaires were sent in English and Arabic languages. Foreign Nigerian students were asked to fill out the English form. The students were invited to complete the English forms of the questionnaires using the online carbon footprint calculator, as well as the translated Arabic forms of the

two questionnaires, which were sent via Google Form format via social networking sites (academic WhatsApp groups). The CF of the nursing students were recorded by collecting the carbon footprint record from each student. The Arabic forms submitted by the students were analyzed by re-entering the data into a website carbon footprint calculator by the researchers. The time needed for filling out the questionnaires for each student was estimated to be 25 to 35 minutes.

10. Ethical Considerations

This study was approved by the Ethics Committee affiliated with the faculty of nursing, Modern for Technology and Information University. Also, an ethical oral and written approval was obtained from the nursing students after informing them about the nature and purpose of the study. The students were also informed that their participation is voluntary; assure the students about the confidentiality of data collected and that they have the right to withdraw from the study at any time without giving any reason.

11. Statistical Design

Analysis of data was performed using Statistical Package for the Social Sciences (SPSS v. 20). Descriptive analysis was carried out using frequency tables, and percentages for qualitative characteristics. Mean, standard deviation. medians, minimum and maximum values were used for quantitative variables. Student's t-test and analysis of variance (ANOVA test) were used to determine the relationship between the mean' student's total carbon footprint and socio-demographic variables. Linear Correlation Coefficient (R) was used for the detection of the correlation between carbon footprint and knowledge score variables in one group. Cronbach's alpha test was used to ensure and find the reliability of the questionnaires, in addition, person correlation coefficient was used to ensure correlation between the components/ domains of the carbon footprint knowledge questionnaire. A value of $P < 0.05$ was considered statistically significant for all analyses.

12. Results of the study:

Table (1): Showed that the mean age of the MTI nursing students was 21.19 ± 2.00 years old. 59.50% were males, and 97.50% were single. Moreover, 69.89% of students did not work during studying, 53.03% lived with friends, in addition, 90.00% had not any health problems.

Table (2): Reported that, the mean father's age of MTI nursing students was 48.21± 17.44 years old; 40.14% of them had higher/University education; 39.43 % had a Governmental work. On other hand, 64.50% of mothers of MTI nursing students did not work; 36.92% had a university education, mean monthly income was 6803.57± 5516.014 EGP. Regarding the place of residence, 61.30% of the families were from a rural area; 55.20% had health problems of family members.

Table (3): Showed that the mean score of the total CF knowledge among nursing students is 14.419± 10.470 with a mean % of 35.17. the importance for measuring the size of CF was the highest mean score of their knowledge subdomain 1.182± 0.931 (39.40%) followed by the category of methods for minimizing CF footprint. 7.802± 6.082 (35.46%).

Figure (2): Illustrated the nursing students` knowledge levels about CF; It was found that, 67.38% of students had a poor level of CF knowledge, 18.64% had an average level of CF knowledge and only 13.98% had good CF knowledge level.

Table (4): As evident from the table, the total CF is analyzed; the total mean carbon footprint of the faculty of nursing students was (**5.874±0.182**) mtCO2/year. The highest category/ component of CF generated by the students was the secondary carbon footprint (2.561±0.136), followed by the household carbon footprint (2.205±0.045). While the mean score of the transportation carbon footprint was (1.108±0.154).

Figure (3): Revealed that secondary CF presented 43. 6% of the total mean parentage of CF was generated by the nursing students; followed by household activities (37.54%), While transportation was represented by 18.86%.

Table (5): Proved that mean CF was higher among male than females' students 5.893 ± 0.662 with statistical significance differences (P<0.038*). Also, students who were living alone had higher mean CF with highly statistically significant differences (P<0.000**). Additionally, the mean CF of the students was associated statistically with their academic year (P<0.015*).

Figure (4): Showed a comparison for the average CF worldwide was 4.8 tons of CO2, while the CF in Egypt was 2.6 tons of CO2; on the other hand, the average CF of the nursing students was 5.8 tons of CO2.

Table (6): Indicated that there was a statistically significant relation between, the father's education level, mother's occupation, mother's education level, monthly income, and place of residence with CF (P< 0.005; 0.016; 0.007; 0.000 and 0.045) respectively.

Table (7): Clarified that there was a statistically significant inverse correlation between the nursing students' knowledge about the definition of CF with total average CF (p<0.008**); also, there was a statistically significant inverse correlation between the nursing students' knowledge about methods of minimizing CF with Household CF, Secondary CF and total average CF (p< 0.012*, 0.018 and 0.030) respectively. There was a statistically significant inverse correlation between the nursing students' total CF knowledge with secondary CF (p <0.040*); and total CF (p <0.017*).

Table (1): Socio-demographic Characteristics of the Faculty Nursing Students

Students' Demographic Characteristics (N. 279)		
Variables	**Level**	**N (%)**
Age by year	- 19: 21 - 22: 24 - 25: 28	173 (62.00%) 83 (29.75%) 23 (8.25%)
	Mean ± SD 21.19 ± 2.008 **Median=** 20.000	
Gender:	- Male - Female	166 (59.50%) 113 (40.50%)
Marital status:	- Married - Single	7 (2.50%) 272 (97.50%)
Academic year:	- First year (1st and 2nd semester) - Second year (3rd and 4th semester) - Third year (5th and 6th semester) - Fourth year (7th and 8th semester)	80 (28.67%) 75 (26.88%) 63 (22.58%) 61 (21.86%)
Occupation:	- Working - Not working	84 (30.11%) 192 (69.89%)
Living with whom (Housing)	- Alone - Family - Friends	39 (14.00%) 92 (32.97%) 148 (53.03%)
Cumulative Grade point average (CGPA):	- Pass D - Good C - Very good B - Excellent A	13 (4.66%) 79 (28.31%) 135 (48.39%) 52 (18.64%)
Presence of any health problems:	- No - Yes	251(90.00%) 28 (10.00%)

Table (2): Socio-demographic Characteristics of the Families of the Faculty Nursing Students

Students Family 'Demographic Characteristics (N. 279)		
Variables	**Level**	**N (%)**
Father' Age:	- Dead	29 (10.40)
	- 43:50 years old	88 (31.54)
	- 51:58 years old	104 (37.28)
	- 59:67 years old	58 (20.79)
	Mean ± SD 48.21±17.44 **Median *x̃*** 53.00	
Father' educational level:	- Dead	29 (10.40)
	- No formal education	25 (8.96)
	- Primary school	13 (4.66)
	- Secondary school	100(35.84)
	- University	112 (40.14)
Father' occupation:	- Dead	29 (10.40)
	- Governmental work.	110 (39.43)
	- Private work.	86 (30.80)
	- Governmental and private work	32 (11.50)
	- Retired.	11 (3.90)
	- Not working.	11 (3.90)
Mother' occupation:	- Working	99 (35.50)
	- Not working.	180 (64.50)
Mother' educational level:	- No formal education	37 (13.26)
	- Primary school	22 (7.88)
	- Secondary school	88 (31.54)
	- University	103 (36.92)
Monthly Income:	- 4000:6000	136 (48.75)
	- >6000: 8000	100(35.84)
	- >8000	43 (15.41)
	Mean ± SD 6803.57± 5516.014 **Median *x̃*** 6500	
Place of residence:	- Urban Status	108 (38.70)
	- Rural Status	171 (61.30)
Health problems of family's members	- Yes	154 (55.20)
	- No	125 (44.80)

Table (3): Distribution of the Nursing Students' According to their Knowledge Domains of Carbon Footprint

Carbon Footprint Knowledge	Max. score	Median	Mean	±	SD	Mean %
Definition of carbon footprint	6.00	0.00	1.896	±	2.471	31.60
Importance for measuring the size of carbon footprint	3.00	1.00	1.182	±	0.931	39.40
Factors contributing to carbon footprints	10.00	3.00	3.537	±	3.515	35.37
Methods for minimizing our carbon footprint	22.00	8.00	7.802	±	6.082	35.46
Total	41.00	14.00	14.419	±	10.470	35.17

Figure (2): The Level of Nursing Students` Knowledge about Carbon Footprint

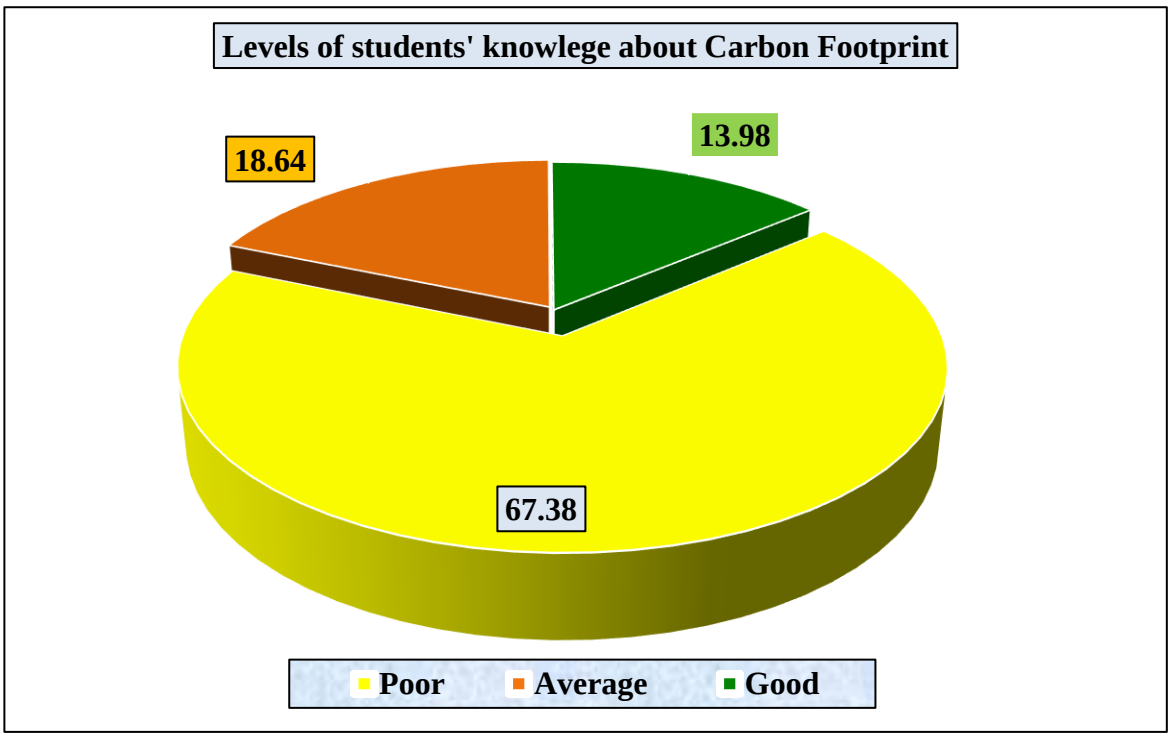


Table (4): Carbon Footprint among the Faculty Nursing Students

Categories of carbon footprint (TonCo2e)	Min. obtained score	Max. obtained score	Mean	±	SD
Household carbon footprint	2.08	2.36	2.205	±	0.0454
Transportation carbon footprint	0.90	1.80	1.1080	±	0.1545
Secondary carbon footprint	2.17	2.98	2.5614	±	0.1368
Total Carbon footprint	**5.15**	**6.67**	**5.8744**	±	**0.1824**

Figure (3): Mean percentage of Carbon Footprint Sectors among the Faculty Nursing Students

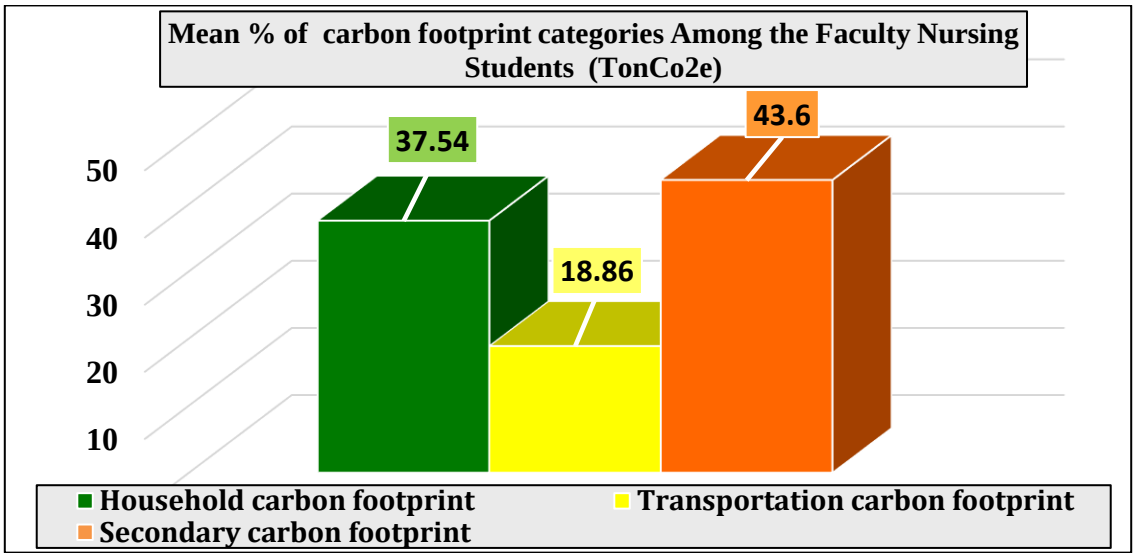


Figure (4): Comparison for the Carbon Footprint Average on Worldwide, Egypt with of the Faculty Nursing Students

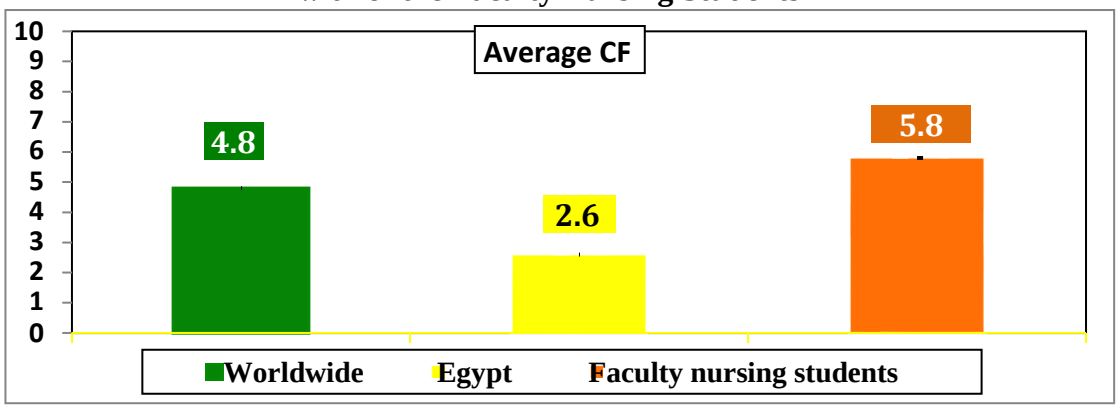


Table (5): The Relation between the Faculty Nursing Students' Socio-demographic Variables and Total Carbon footprint

Student' Socio-demographic Variables		Total Carbon foot print			T/F	P-value
Variables	**Level**	**Mean**	**±**	**SD**		
Age	19: 21 years old	5.8754	±	0.18733		
	22: 24 years old	5.8552	±	0.16308	1.788	0.169
	25: 28 years old	5.9361	±	0.20407		
Gender	Males	5.8932	±	0.6624		
	Females	5.8446	±	0.20273	2.084	**0.038***
Marital Status	Married	5.8751	±	0.18241		
	Single	5.7375	±	0.12633	1.502	0.134
Academic Year	First level	5.7678	±	0.0746		
	Second level	5.8623	±	0.17917	3.560	**0.015***
	Third level	5.9788	±	0.20961		
	Fourth level	5.8958	±	0.18335		
Occupation	Not work	5.8997	±	0.56557		
	Work	5.8923	±	0.58823	0.402	0.688
Living with whom (Housing)	Alone	5.9856	±	0.21490		
	Family	5.8512	±	0.14577	8.960	**0.000****
	Friends /roommates	5.8586	±	0.18242		
Grade point average (GPA):	Pass (D)	5.9810	±	0.2864		
	Good (C)	5.8751	±	0.16832	1.619	0.185
	Very Good (B)	5.8808	±	0.18778		
	Excellent (A)	5.8463	±	0.15574		
Presence of Health Problems	No	5.8700	±	0.17986		
	Yes	5.9136	±	0.20333	-1.200	0.231

(*) P-value significant at the 0.05 level,
(**) P-value significant at the 0.01 level,
T. t test, **F**. Anova test

Table (6): The Relation between the Faculty Nursing Students' Family' Socio-demographic Variables and Total Carbon Footprint

Family' Socio-demographic Variables		Carbon footprint	T/F	P-value
Variables	**Level**	**Mean± SD**		
Father's Age	Dead	5.9069 ± 0.19796	1.731	0.102
	43:50 years old	5.8764 ± 0.16176		
	51:58 years old	5.8835 ± 0.18854		
	59:67 years old	5.8797 ± 0.18036		
Father's occupation	Dead	5.8707 ± 0.12925	0.397	0.850
	Governmental work	5.8569 ± 0.15499		
	Private work	5.8884 ± 0.22346		
	Governmental & private work	5.8863 ± 0.20075		
	Retirement	5.8727 ± 0.12916		
	Didn't work	5.8733 ± 0.18295		
Father's education level	Dead	5.8980 ± 0.22054	3.834	**0.005****
	No formal Education	5.8900 ± 0.11091		
	Primary Education	5.8033 ± 0.18235		
	Secondary Education	5.8861 ± 0.19273		
	Higher Education	5.9056 ± 0.15528		
Mother' occupation	Working	5.9096 ± 0.15434	2.412	**0.016***
	Housewife	5.8550 ± 0.19385		
Mother's education level	No formal education	5.7988 ± 0.18445	3.626	**0.007****
	Primary education	5.8497 ± 0.18288		
	Secondary education	5.8798 ± 0.18522		
	Higher education	5.8897 ± 0.19074		
Monthly Income	3000:5000	5.8202 ± 0.13652	43..482	**0.000****
	>5000: 8000	5.9585 ± 0.18497		
	>8000:12000	6.1124 ± 0.25165		
Place of Residence	Urban/ Suburban	5.9507 ± 0.18683	1.988	**0.045***
	Rural	5.8077 ± 0.17812		
Presence of health problems	No	5.8915 ± 0.18083	1.586	0.114
	Yes	5.8565 ± 0.18430		

(*) P-value significant at the 0.05 level
(**) P-value significant at the 0.01 level,
T. t test, **F**. Anova test

Table (7): The Association between the Faculty Nursing Students' CF Knowledge Subdomains with their and Mean Carbon footprint Categories

CF Categories CF knowledge Subdomains		Household CF	Transportation CF	Secondary CF	Total CF
Definition of CF	r	-0.007	-0.105	-0.090	- 0.158
	p	0.913	0.081	0.134	**0.008****
Importance for measuring the size of CF	r	0.047	0.071	-0.005	0.068
	p	0.430	0.235	0.931	0.255
Factors contributing to CF	r	0.036	0.073	-0.056	0.029
	p	0.546	0.224	0.349	0.633
Methods for minimizing CF	r	-0.172	-0.006	-0.142	-0.130
	p	**0.012***	0.916	**0.018***	**0.030***
Total knowledge of CF	r	-0.027	0.003	-0.123	-0.147
	p	0.655	0.966	**0.040***	**0.017***

CF. Carbon footprint
(*) Correlation is significant at the 0.05 level (2-tailed).
(**) Correlation is significant at the 0.01 level (2-tailed).

13. Discussion:

There is no doubt that academic institutions assume a crucial and significant role hoping to enable society to face climate change and environmental challenges [24]. Faculty nursing students should recognize the importance of sustainability knowledge and advocate for sustainable development, the awareness and integration of nursing students to sustainability goals can empower other students to pursue these goals outside the university, creating a positive spillover effect [25]. A very limited number of studies have been studying the effect of knowledge about carbon footprint and calculating CF for each nursing student during the academic year.

Regarding demographic characteristics of the nursing students, the results of the study revealed that male students represented more than half of the study subjects. This finding refers to that there is a gradual increase in the number of male nursing students and no longer be an exclusively female profession. This result is supported by **Moselhy, (2021)** [26], who found in her Egyptian study among nursing students, that more than half of the study subjects were males. While this finding contradicted **Ahmed et al., (2018)** [27], who found in their study a high percentage of nursing students were female.

It was clear from the study finding that the majority of the parents of the nursing students had a high educational level with a mean monthly income was 6803.57 EGP. Regarding housing, more than two-thirds of the nursing students lived either with their friends or alone, and few of them lived with their families since more than half of them were from rural areas. Besides the MTI faculty of nursing is concerned to receive foreign students from different

countries such as Nigeria. According to the Egyptian study by **Mahmoud et al., (2020)** [28], more than half of the studied nursing students were from rural areas.

Concerning knowledge of carbon footprint among the nursing faculty students, unfortunately the findings of the present study showed that more than two-thirds of the nursing students had a poor knowledge level about CF with low means scores in all CF knowledge domains specifically, related to the CF concept. This finding supports the fact that there is a lack of awareness about the concept of CF, and it's not sufficiently widespread. This could be partly related to the shortage of formal education about climate change in schools, and higher education. In nursing studies, the concept of environmental health tends to be studied with a deep focus only in the community health department regardless of other nursing departments. As well as, the lack of environmental prioritization in the country's national policies could be a factor, as it was noted by **El-Gamal, (2021)** [29] that, environmental issues and climate change were not at the top of the Egyptian state's priorities until a few years ago. The result of the present study agreed with **Wijesinghe et al., (2021)** [3] who found that the knowledge of CF was inadequate among medical students in Sri Lanka, and only 33.2% knew the meaning of CF. In addition, according to **the American Association of Colleges of Nursing (2011)** [30], the calculation of carbon footprint and its composition is a new term for students.

The validated web-based carbon footprint calculator for users was applied in the present study, which focuses mainly on household energy consumption, transportation, and secondary footprints. Results of the current study revealed that secondary CF was the highest sector of CF consumed among nursing students. ***Secondary CF*** measures the indirect CO2 emissions from the whole lifecycle-based products of manufacture, and breakdowns of services, such as food and drink products, pharmaceuticals, clothes, restaurants, mobile/phone, call costs, paper-based products; computers, and IT equipment; in addition, education, recreational, and sporting activities. From the researcher's perspective, numerous factors could be contributed to the elevation of the secondary CF among the students, mainly the nature of academic activities of the nursing students such as printing, writing notes, examinations, and electronic learning. Additionally, lifestyle choices among the students from the way of eating and food preferences focus on take-away food and meat-rich diets. According to **Qafisheh et al., (2017)** [21], food is a major contributor to CF, particularly meat processing responsible for a significant amount of CO2 emissions, and beef is one of the biggest contributors. In addition, personal consumption of clothing, footwear, and goods accounts for a significant amount of individuals' CF resulting from CO2 emissions from gathering materials, production, and transport. This result revealed that nursing students are in desperate need of educational programs about the effects of lifestyle choices on climate change and CO2 emissions.

Household energy was the second component of CF consumed by nursing students,

certain household activities lead to increasing CO2 emissions such as the consumption of water, electrical appliances, air conditioners, and fuel combustion with cooking. While ***transportation*** was the least CF sector consumed by the nursing students which presented 18.68% of total CF. This may be due to more than half of the students living with their friends shared in rented houses near the faculty, commuting on foot or leaving the university together in groups and sharing either personal or public transportation near the university or even using the university's bus for transportation. This finding is quite similar to the Chinas study by **Li et al., (2015)** [31] that found transportation portion account was 20% of total CF among Tongji university students.

Based on this finding, it was obvious that the primary/direct sources (household and transportation) caused more than half of nursing students' Carbon footprint and the remainder of students' CF resulted from secondary/indirect sources. This finding was similar to Turkan's study of **Basol, (2017)** [32] conducted among university staff that revealed more than half of CF emission comes from the primary sources. According to **Boehm et al., (2018)** [33] **and Jones & Kammen (2011)** [34]**,** food as a secondary CF source, represents a higher portion in lower-income countries, while transportation accounts for the least component of CF. On the other hand, in developed countries, such as the United States approximately 40 % of total emissions during the first decade of the 21st century was from primary sources including transportation and household energy, the remainder of an individual's CF was come from secondary carbon footprint, representing carbon emissions associated with the consumption of goods and services **(Selin, 2022)** [35]**.**

Accordingly, the results of the current study revealed that the average total means carbon footprint of the faculty nursing students at MTI University was 5.87 mt/CO2/year, which was higher than the average world carbon footprint, and more than two-fold higher than Egypt's CO2 emission per capita average of 2.69 mt/CO2/year **(World Data Atlas, 2020)** [36]. The average CF of nursing students detected in the present study was nearly similar to the mean CF of medical students at the University of Colombo, Sri Lanka **(Wijesinghe et al., 2021)** [3]. While, it is much lower than the average CF among university staff in turkey which was 12.069 tons per person **(Basol, 2017)** [32]. On the other hand, the mean CF of nursing students in the present study seemed to be higher than the average CF of the students who studied humanities, at the Norwegian University of Technology and Science **(Larsen et al., 2013)** [37]**.** This difference could be related to the differentiation of lifestyle (life cycle-related activities) and field of study among participants in the different countries, as studies of health science-oriented programs require the usage of more equipment and activities.

Concerning the relation between demographic data and total CF among nursing students, the present study finding showed a statistically significant relationship between students' gender and CF, from which male students had higher mean CF than female students. This could be because men tend to purchase goods with larger carbon footprints, and spent more money on tobacco and more energy fuels for a personal car which is one

of the main sources of the production of greenhouse gases. In contrast, females tend to use public transposition. This finding was similar to a Swedish study conducted by **Carlsson et al., (2021)** [38], who found that men's spending on goods causes 16% more emissions than women, as men spend a lot more money (70% more) on greenhouse gas intensive items such as fuel. Moreover, **Ho, (2021)** [39] mentioned that single men, generally use more car fuel than single women for transport and holidays, further adding to their hefty footprint. furthermore, **Toro et al., (2019)** [40] found in their study that men's total GHG footprint is higher, with the greatest difference found in purchasing personal vehicles and transport services.

The study results revealed that CF was higher among the nursing students with a higher level of the academic year, this could be attributed to the academic activities and requirement that is more complex with the advancement of the academic year. Noteworthy, the results also showed that CF was also higher among the nursing students who lived alone compared with those who lived either with their families or friends with a statistically significant difference. This could be explained by the fact that when people live together, they share households' activities such as energy needed for electricity, heating and cooling, water, waste collection, appliances, equipment, and cooking tools, which leads to saving resources efficiently, Hence, reduce the carbon emissions per person. This finding was supported by **Ivanova and Büchs, (2020)** [41] who found in their study, that one-person households have the highest CF per person compared to other types of households. The average CF per capita of a one-member household is about twice that of a five- or more person household.

The mean score of CF among nursing students remarkably elevated with the increment of family income and elevation of the educational level of their parents. Also, a statistically significant relation was found between mothers' occupation and CF, as working women contribute to raising the economic level of the family. In this regrade, the result clarified that a higher socioeconomic level is associated with increased consumption of energy from various primary or secondary CF. This finding corresponded with Koide et al., (2019) [10], who found in their study that higher households' incomes were likely to have larger footprints with statistical significance. Furthermore, **Kelvey, (2020)** [42], increasing education in the developing countries could lead to a modest increase in carbon emissions due to economic growth.

Intriguingly, place of residence is an important driver of individual CF in which urban residents of nursing students had a higher mean CF than rural residents. This could be due to the effect of urbanization and elevated socio-economic status. This result matched with **Huanga and Tianc, (2020)** [43], who found that more than half of the CO_2 emissions are caused by the urban households in China, India, Indonesia, and South Africa. While the result contradicted **Pang et al., (2019)** [44] who found in their study that Swiss urban households tend to have lower direct emissions than rural households whereas indirect

emissions are higher. Also, **Ottelin et al., (2019)** [45], found that CF in Europe are 7% lower in cities than in rural areas. The differences are attributed to the discrepancies in economic status and demographic distribution in rural and urban between different developing and developed countries.

There was a statistically significant inverse correlation between the nursing students' CF knowledge with their average CF emission, which means lower CF knowledge level was associated with higher average CF among nursing students and vice versa. The study result showed that when the students have higher CF knowledge specifically regarding methods for minimizing CF, they can save and rationally use household energy and secondary life cycle-related CF. According to **Chuvieco et al., (2021)** [46], Climate change knowledge significantly impacted the CF of clothing and food, which is related to a consumerism mentality. In this respect, increasing awareness and knowledge about climate change and CF is critically needed to empower nursing students to take action for minimizing CF, hoping to mitigate climate change.

14. Conclusion and Implication

The study concluded that the majority of the nursing students had poor knowledge about CF and climate change. Additionally, the average CF per capita among nursing students was higher than the average CF worldwide and two-fold higher than Egypt's CO_2 emission per capita. The nursing academic requirements and higher socioeconomic level could attribute to the higher CF among the nursing students. Importantly, poor CF knowledge could prohibit, nursing students from taking effective measures to reduce their CF and that of others as part of the responsibility of future health care professionals.

15. Recommendations:

- Updating the universities' nursing curriculum and courses with the global environmental issues, to be studied at all nursing levels with different specialties in the faculty of nursing, with a deeper and broader focus on nurses' responsibility toward mitigation strategies for climate change and reduction of humanity’s CF, to empower nursing students with the knowledge, and skills, to advocate for a greener planet, as better preparedness for future health leaders of society while saving and reducing their carbon footprint as a good example for others.
- Awareness program should be conducted for the nursing students to improve the knowledge about methods of climate change mitigation and CF reduction
- Large-scale projects are needed to face increasing CF, investigation and calculation of carbon footprint among all students affiliated to MTI University.

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Conflict of Interest:

The authors declare that they have no competing interests.

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الملخص العربي

معلومات وحساب البصمة الكربونية لدى طلاب التمريض

الخلفية: يتحمل الممرضون والممرضات كعضو أساسي في فريق الرعاية الصحية مسئولية بارزة وهامة في الحفاظ على صحة البيئة واتخاذ كافة الاستراتيجيات والاجراءات لمكافحة التغيرات المناخية وتقليل البصمة الكربونية لدى الافراد، ولذلك يجب ان يتم تأهيل طلاب التمريض منذ بداية سنواتهم الدراسية للقيام بهذا الدور الحيوي كقائد ومدافع عن البيئة الصحية. ولكن نجد أن نصيب او معدل استهلاك الفرد للبصمة الكربونية بين طلاب التمريض كنموذج مثالي يجب ان يحتذى به غير معروف، وما إذا كانوا على دراية جيدة بالمعلومات والتدابير الفعالة للحد من معدل الانبعاثات الكربونية.

الهدف: تقييم معلومات وحساب انبعاثات البصمة الكربونية لدى طلاب التمريض

أسئلة البحث: (1) ما هو مستوى درجة المعلومات تجاه البصمة الكربونية لدى طلاب التمريض؟

(2) ما هو متوسط البصمة الكربونية للفرد بين طلاب التمريض؟

منهجية البحث: تم تطبيق تصميم بحث وصفي تحليلي باستخدام عينة عشوائية بسيطة طبقية على 279 طالب من كلية التمريض بالجامعة الحديثة للتكنولوجيا والمعلومات .تم استخدام أداتين لجمع البيانات: (1) استبيان طلاب كلية التمريض يتكون من قسمين لتقييم الخصائص الديموغرافية للطلاب وعائلاتهم. بالإضافة إلى تقييم المعلومات لدى الطلاب تجاه البصمة الكربونية والتدابير اللازمة لمكافحة والحد من التغير المناخي. (2) حاسبة البصمة الكربونية بين طلاب التمريض.

النتائج: 67.38٪ من الطلاب لديهم مستوى ضعيف من المعلومات، بلغ متوسط البصمة الكربونية لطلاب التمريض 5.874 ± 0.182 طن متري من ثاني أكسيد الكربون / سنة .ارتبطت العديد من المتغيرات الديموغرافية للطلاب وعائلاتهم إحصائيًا بمتوسط البصمة الكربونية للطلاب " الجنس، والعيش بمفرده، والمستوى التعليمي للوالدين، ومهنة الأم، الدخل الاسرى، ومكان إقامة. وكذلك اظهرت نتائج الدراسة وجود علاقة عكسية ذات دلالة احصائية بين مستوى معلومات الطلاب حول البصمة الكربونية مع متوسط نصيب الفرد منها

الخلاصة: غالبية طلاب التمريض لديهم معلومات ضعيفة تجاه البصمة الكربونية بالإضافة إلى ذلك، وجد ان متوسط نصيب الفرد من البصمة الكربونية بين طلاب التمريض أعلى من متوسط البصمة الكربونية العالمية وكذلك أعلى بمرتين من معدل الانبعاثات الكربونية للفرد على المستوى المحلى في مصر.

التوصيات: تحديث مناهج كليات التمريض بالقضايا البيئية العالمية، مع التركيز بشكل أعمق على مسؤولية الممرضات تجاه الاستراتيجيات المبتكرة لخفض البصمة الكربونية

الكلمات المفتاحية: طلاب التمريض، البصمة الكربونية، التغيير المناخي