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Knowledge and Health-Related Behaviors toward Climate Changes and Heat Stress among Pregnant Women Working Outdoors: Tailored Educational Program

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Abstract
Background: Climate change is the greatest threat to public health in the twenty-first century which puts pregnant mothers and their developing fetus at serious risk. Pregnant women's health may be improved by educating them about the hazards involved in their pregnancy. **Aim:** was to investigate the effectiveness of tailored educational program on knowledge and health-related behaviors toward climate changes and heat stress among pregnant women working outdoors. **Design:** A quasi-experimental research design. **Setting:** This research was conducted at obstetrics and gynecological outpatient clinic at Benha University Hospital in Qaliobya governorate, Egypt. **Sample:** A purposive sample of 108 pregnant women, control group (n=54) and study group (n=54) **Tools:** Four tools were used for data collection; A structured self-administered questionnaire, Maternal knowledge assessment sheet, Maternal health-related behaviors questionnaire, Adverse pregnancy outcomes questionnaire. **Results:** showed that there was a highly statistically significant difference between study and control groups regarding their knowledge and health-related behaviors about climate changes and heat stress after implementation of the tailored educational program. Additionally, there was a statistically significant difference between study and control groups regarding adverse pregnancy outcomes. **Conclusion:** Tailored educational program had a positive effect on the improvement of pregnant women's knowledge and health-related behaviors about climate changes and heat stress. Furthermore, there was a statistical significant reduction in the adverse pregnancy outcomes between study and control groups after applying tailored educational program. **Recommendations:** Establishing and maintaining effective antenatal care in the face of harsh life circumstances through new educational interventions to lessen the detrimental effects on maternal and fetal health which brought on by the climate changes conditions.

Keywords: ***Climate Changes, Heat Stress, Health-Related Behaviors &Tailored Educational Program***

Introduction
Pregnancy is the most beautiful and gratifying occurrence in the life of women, is an essential event that demands exceptional attention from the point of conception to the postnatal period. Although pregnancy may occur spontaneously, it does not necessarily imply that it is devoid of any complications. Even a minor discomfort can potentially escalate into severe complications, and the symptoms of such discomforts differ from one woman to another. **(El-Eefaey et al., 2020)**.

Workers, particularly pregnant women who engage in outdoor working, are often the initial individuals to encounter the consequences of climate change. This exposure is characterized by longer durations and heightened intensities, which may ultimately contribute to the manifestation of unfavorable outcomes during pregnancy. Previous research has provided evidence that climate change can precipitate a reduction in the ozone layer, consequently affecting the levels of ultraviolet (UV) radiation on the Earth's surface. Consequently, this can cause outdoor workers may be subjected to more frequent, intense, and prolonged exposure to UV radiation, thereby increasing the susceptibility to deleterious effects on both maternal and fetal well-being, as well as potentially compromising immune function **(Moda et al., 2019)**. Additionally, the exposure to elevated temperatures accompanied by increased instances of heat may result in greater heat stress, potentially precipitating a greater incidence of heat-related illnesses such as heat stroke, heat exhaustion, heightened susceptibility to chemical exposure, and fatigue **(Helldén et al., 2023)**.

Climate change represents a significant global health threats to the world's population. The occurrence of climate change is primarily instigated by global warming, predominantly caused by the escalation of greenhouse gases levels that stem from human activities. These activities encompass combustion of fossil fuels (carbon dioxide), the rearing of animals leading to the release of methane through manure, the emissions from various industries such as (ozone, nitrogen oxides, sulfur dioxide), as well as the

expulsion of vehicular and industrial exhaust, and the presence of chlorofluorocarbon aerosols, which have the capacity to retain excess heat within the earth's atmosphere **(National Centers for Environmental Information (NOAA), 2022).**

Elevated temperatures surpassing a specific threshold have been documented to elicit stress responses related to heat. Additionally, the endocrine response may be influenced by heat stress, consequently impacting the immune response in pregnant women **(Moffett & Shreeve, 2022)**. Exposure to heat appears to diminish progesterone concentrations, which primarily inhibits the production of pro-inflammatory cytokines by local immune cells, subsequently leading to the induction of more tolerogenic phenotypes in dendritic cells and promoting immune tolerance through the induction of immunomodulatory molecules at the interface between the mother and the developing fetus. A decline in progesterone levels subsequently initiates a shift towards an inflammatory immune response during the early stages of pregnancy, resulting in reduced tolerance towards the fetus. Ultimately, this favors fetal loss and contributes to the development of heat-induced preterm birth **(Syed et al., 2022)**.

The number of heat waves experienced annually in the United States has witnessed a substantial rise over the years. Initially, in the 1960s, the average annual count stood at two, whereas in the 2010s, this figure escalated to six. In addition to the increase in frequency, the length and average temperature of individual heat waves have also demonstrated significant growth in recent decades. Furthermore, it is crucial to acknowledge the impact of these heat waves on specific groups of individuals, namely women, pregnant women, children, the disabled, and the elderly, who are particularly vulnerable to their effects **(Haynes et al., 2022).**

In addition, climate change is caused by various factors, including manufacturing and industry, as well as the escalating levels of greenhouse gases. For instance, carbon dioxide (CO2) is released into the atmosphere through the combustion of fossil fuels for transportation and heating purposes, while methane emissions primarily originate from livestock raised for the meat industry. The Egyptian Meteorological Service recently published a report highlighting the unprecedented surge in temperatures during the summer of 2021, occurring five years prior, where average temperatures surpassed the norm by approximately 3-4 degrees. As a result, the Egyptian government has been compelled to adopt more rigorous and efficacious measures in order to effectively mitigate and adapt to the adverse consequences of climate change. **(Al-Ahram Center for Political & Strategic Studies (ACPSS), 2021).**

The impact of climate change and heat stress on human health is a phenomenon that is widespread and has implications in various areas such as social, economic, political, geographical, ecological, and psychological domains **(Giudecca et al., 2021).** Additionally, the risks posed by climate change to health encompass factors like air pollution, forced migration, disruption of families, violence, and changes in patterns of infectious diseases, which can compromise both physical health and mental well-being and limit the capacity of civil society to ensure the safety of its citizens. These effects are particularly likely to affect vulnerable populations **(Aronsson et al., 2020).**

Pregnant women exhibit a high susceptibility to adverse environments. The available body of evidence emphasizes that rising temperatures which are directly linked to the persisting climatic shifts, manifest a peril to the accomplishment of successful reproduction. Heat stress brought on by an escalated ambient temperature can bring about unfavorable outcomes during pregnancy, such as preterm labor, low birth weight, stillbirth, abortion, hypertensive disease and placenta abruption. **(Yüzen et al., 2023).** Maternity nurses play a crucial role in providing guidance to pregnant women regarding the recognition of climate change indicators and symptoms of heat stress. Furthermore, they emphasize the significance of maintaining proper hydration levels before, during, and after their work shifts, as well as the importance of consuming a well-balanced and nutritious diet along with an adequate intake of fluids. These nurses also stress the importance of taking breaks at appropriate intervals, monitoring hydration levels and using personal protective equipment (PPE) in conjunction with protective clothing, such as cotton garments, when working outdoors. Lastly, they emphasize the necessity of seeking medical advice when needed **(Abo Khashabah et al., 2020).**

Significance of the study:

Climate change is anticipated to lead to a higher occurrence and heightened severity of climate-related environmental disasters, including but not limited to heat waves, wildfires, and extreme weather incidents such as drought, hurricanes, and food scarcity, resulting in adverse pregnancy outcomes such as anemia, eclampsia, low birth weight, preterm birth and potentially even miscarriage **(Glaser et al., 2022).**

The incidence of climate change and heat related death is increasing with climate change, particularly for pregnant women during the summer. The annual average number of pregnant women who succumbed to heat-related deaths in the United States from 2014

to 2020 amounted to 702. High heat exposure was a contributing cause of death in addition to chronic medical conditions. From 1998-2021, more than 166.000 pregnant women died due to heat related illness, including more than 70000 who died during 2003 heat wave in Europe **(Vaidyanathan et al., 2020).**

The crisis of the Egyptian Ministry of health confirmed during the year (2021) that the number of deaths due to heat stress reached 95 cases and 1914 injured, since the beginning of the heat wave**,** and the most of deaths, most of them are over the age of 60 years, and among them are pregnant women in different months of pregnancy, and most of them suffer from pathological problems due to failure or decline in the heart muscle or chronic high blood pressure **(Abo Khashabah et al., 2020).**

Such research has not been conducted before at Benha university hospitals. So, this study aims to investigate effect of tailored educational program on knowledge and health-related behaviors toward climate changes and heat stress among pregnant women working outdoors.

Aim of the research

This research aimed to investigate the effectiveness of tailored educational program on knowledge and health-related behaviors toward climate changes and heat stress among pregnant women working outdoors.

Research Hypotheses:

H1: Pregnant women who will receive tailored educational program will exhibit improved knowledge regarding climate changes and heat stress after implementation of program than those who don't.

H2: Pregnant women who will receive tailored education program will exhibit satisfactory level of health-related behaviors regarding climate changes and heat stress after implementation of program than those who don't.

H3: Pregnant women who will receive tailored educational program will exhibit less climate changes' adverse pregnancy outcomes after implementation of program than those who don't.

Operational definitions:

Tailored educational program: a systematically designed program, in which the pregnant women who are working outdoors participate in collaborative cycles of education to enhance their knowledge and health-related behaviors regarding climate changes and heat stress.

Health-related behaviors: activities and self-care practices that are carry out regularly and repeatedly by pregnant women with the intention of reducing climate changes' adverse pregnancy outcomes

Subjects and Method

Research Design:

A quasi-experimental research design (two groups "control/study", ″pre –posttest″) was utilized to achieve the research aim.

Research Setting:

The research was carried out at obstetrics and gynecological outpatient clinic in Benha University hospital in Qaliobya governorate, Egypt. The setting comprises a single floor that is divided into four distinct sections: the reception area, the antenatal examination section, the gynecological examination section, and a room designated for nursing staff. The official operating hours of the antenatal clinic commence at 9 am and conclude at 12 pm on a daily basis. For routine antenatal care, two nurses and four obstetricians (consisting of a consultant, specialist assistant, specialist, and one junior doctor) provide their services.

Sampling:

Sample type and criteria: A purposive sample of pregnant women was chosen from the aforementioned research settings; according to following **inclusion criteria:**

- Only pregnant working outdoors (as working as an agricultural worker; outside work on a small-hold farm; gardening for at least 3 hours.
- Confirmed pregnancy with live single fetus
- Pregnant women in the 1st and 2nd trimester.
- Free from any medical complications.
- Free from any psychological disease.
- Can read and write.

Sample Size and technique: All pregnant women who were admitted to the previous setting for duration of six months, totaling 108 women, were included in the study after excluding those who did not meet the inclusion criteria. To ensure unbiased data collection, pregnant women who were admitted to the antenatal clinic within the first three months and met the inclusion criteria from the beginning of data collection were recruited for the control group (n=54). Similarly, pregnant women with the same criteria who were admitted during the second three months of data collection were recruited for the study group (n=54).

Tools of data collection:

Four main tools were utilized for gathering data:

Tool I: A structured self-administered questionnaire: it was developed by researchers after reviewing advanced related literature and subsequently translated into Arabic language. It included two parts:

Part (1): **General characteristics of studied women:** such as (age, place of residence, educational level, family income and sources of information).

Part (2): **Obstetrical history:** it consisted of **(**current gestational age, number of gravidity, number of parity).

Tool II: Maternal knowledge assessment sheet (pre/posttest): It was designed by researchers after reviewing a related literature **(Mannocci & Cimmuto, 2020)** to assess pregnant women's knowledge regarding climate change and heat stress, it consisted of two parts:

Part (1): Knowledge regarding climate change: it consisted of (9 questions) such as (concept of climate change, causes, gases that cause climate change, images of climate change, psychological effect of climate change on the health of pregnant women, Physical impact of climate change on the health of pregnant women, Adverse effect of climate change on the health of fetuses, People most affected by climate change and individual measures to limit climate change).

Part (2): Knowledge regarding heat stress: it consisted of (7 questions) such as (concept of heat stress, causes, symptoms, diagnosis, complications, ways to prevent exposure to heat stress and ways to overcome heat stress related to climate change).

Scoring system:

All the knowledge items were assigned weights according to the items included in each question, which were in the form of (multiple choice questions). Each item was assigned a score of (2) if the answer given was correct and a score of (1) if the answer was incorrect answer or don't know. The total score was then calculated by adding up the scores of all the questions.

Total knowledge score was classified as the following:

- Good: > 60 % - 100% (Score > 20)
- Average: 50≤ 60 % (Score 16 < 20)
- Poor: < 50 % (Score < 16)

Tool III: **Maternal health-related behaviors questionnaire (pre/posttest):** It was adapted from **(Tiong et al., 2020)** and translated into Arabic language. It was used to assess health-related behaviors of pregnant women regarding climate change and heat stress, it consisted of two parts:

Part (1): Health-related behaviors regarding climate change: it consisted of 26-items has **five subscales** that focus on different areas of maternal health-related behaviors regarding climate changes. **These subscales were:** General measures (6- items), Nutritional practices (4- items), Clothes and protective tools (6- items), Daily activities and sports (8- items) and Resorting to medical care (2- items).

Part (2): Health-related behaviors regarding heat stress: it consisted of 24- items have **five subscales** that focus on different areas of maternal health-related behaviors regarding heat stress. **These subscales were**: Measures in case of sunstroke (6- items), Measures in case of heat exhaustion (4- items), Measures in case of sun burn (6- items), Measures to avoid heat cramps (8- items) and Measures to avoid heat cramps (2- items).

Scoring system:

Each item was judged according to a three-point Likert scale continuum. Each item was given a score (3) if it was always practiced, a score (2) if it was practiced sometimes, and a score (1) if it was never practiced. The overall score for health-related behaviors was calculated by summing up the scores for each item. The obtained scores ranged from 50 and 150, with higher scores indicating a greater level of involvement in healthy behaviors. **Total practices score was classified into two levels:**

- Satisfactory level: (≥ 60% -100%). Score of ≥ 90.
- Unsatisfactory level: (< 60 %). Score of < 90.

Tool IV: Adverse pregnancy outcomes questionnaire: it was developed by the researchers to evaluate occurrence of adverse pregnancy outcomes in both study and control group after intervention throughout and till the end of pregnancy journey; including (anemia, preterm birth, gestational hypertension, intrauterine growth retardation, antepartum hemorrhage, antepartum fetal distress, hyperemesis gravidarum, recurrent infections, altered nutritional composition, low birth weight, sleep deprivation and reduced quality of sleep, increased emergency hospital admission, fatigue and exhaustion and psychological anxiety and stress). For assessment of each adverse pregnancy outcome, the women answered with "yes" or "no"; except for assessment of psychological anxiety and stress level and fatigue, a visual analogue scale (VAS-A) was used. Participated women were given instructions to select a numerical value ranging from 0 to 10 that most accurately represents the intensity of their anxiety. A rating of (0) would mean "absence of anxiety ", while a rating of 10 would indicate a state of "severe anxiety". **The obtained scores were subsequently categorized as follows:** absence of anxiety (0), mild anxiety (1-3), moderate anxiety (4-7), and severe anxiety (8-10). **(Hernández- Palazón et al, 2015).**

Administrative approval:

A formal written approval was obtained from the dean of the faculty of nursing and subsequently conveyed to the director of the Benha University Hospital. Subsequently, it was presented to the director of the department of Obstetrics and Gynecology to obtain their consent to conduct the

study, following a comprehensive explanation of its purpose.

Tools validity and reliability:

A panel consisting of three experts in the field of obstetrics and gynecological nursing from Benha University were evaluated the questionnaire's validity in order to ensure their clarity, comprehensiveness, relevance, and applicability. Some modifications were required in sentence formulation. According to the experts' viewpoint, the validity of the tools was deemed acceptable. The reliability was carried out using Cronbach's Alpha coefficient test, which indicated that the internal consistency of maternal knowledge questionnaire was 0.89, the internal consistency of maternal health-related behaviors was 0.80, and the internal consistency of adverse pregnancy outcomes questionnaire was 0.74.

Ethical consideration:

Ethical considerations will be taken into account prior to commencing the study as follows: The research has obtained approval from scientific research ethical committee of the faculty of nursing at Benha University in order to fulfill the research requirements. Official permission has been obtained from the selected research settings in order to fulfill the research requirements. Prior to utilizing the tools, the researchers explained the aim and significance of the research to gain women's confidence and trust. The researchers have obtained verbal consent from women to participate in the research, ensuring confidentiality. The research didn't have any physical, social or psychological risks on the women. All data collection tools have been burned following statistical analysis to safeguard confidentiality of the participating women. The research tools have been designed to ensure that no harm is inflicted upon any women during data collection. Furthermore, the research does not include any immoral statements and respect human rights. The women have the freedom to withdraw from the research at any given time.

Pilot study:

A pilot study was undertaken over duration of three weeks, which accounted for 10% of the total sample. The purpose of this study was to assess the clarity, objectivity, feasibility and applicability of the research tools. Additionally, it aimed to identify any potential obstacles or issues that could face the researcher and identify any specific problems related to the sequence of questions and clarity. It also helped to assisted in estimating the necessary time for data collection. Subsequent modifications were made based on the findings of the pilot study. To prevent any contamination of the sample, the pilot sample was excluded from the final study.

Field work:

The research was carried out from the beginning of January, 2023 and completed at the end of June 2023 covering six months. The researchers conducted the study two times/ week (Mondays and Wednesdays) from 9.00 a.m. to 12.00 p.m. at previously mentioned setting until the predetermined duration was completed. The researchers conducted interviews with the women in small in order to implement the tailored educational program regarding climate change and heat stress. Upon the conclusion of this research, the handout (booklet) about climate change and heat stress was left at the outpatient clinic to be distributed among all pregnant women, so the benefit is spread.

In order to accomplish the objective of this research, the subsequent stages were adopted; preparatory phase, interviewing and assessment phase, planning phase, implementation phase and evaluation phase.

The Preparatory phase:

Represents the initial phase of the research. During this phase, the researchers conducted a thorough review of both local and international literature pertaining to the research problem. This facilitated the researchers to be acquainted with magnitude and seriousness of the problem, and guided the researchers to prepare the required data collection tools. These tools were then distributed to three experts specializing in the field of obstetrics & gynecological nursing at faculty of Benha University; the aim was to test the appropriateness, comprehensiveness, clarity, importance and applicability of the tools. The results of the jury were subsequently obtained from the panel of experts.

Interviewing and assessment phase:

At the beginning of the interview the researchers welcomed the woman, introduced themselves to each pregnant woman encompassed in the research, explained the aim of the research, provided the woman with all information about the research and took verbal consent to participate in the research. The pregnant women were given **tool (I):** to assess general characteristics of pregnant women and obstetrical history. Then, the researchers used **tool (II): (as pretest)** to assess pregnant women's knowledge regarding climate change and heat stress and **tool III: (as pretest)** to assess health-related behaviors of pregnant women regarding climate change and heat stress. The time taken to complete the questionnaires on average was approximately between (30-40 minutes). The data collected during this phase served as the baseline for subsequent comparisons to evaluate the effect of the tailored education program. However, **Tool IV:** was utilized to evaluate occurrence of adverse pregnancy

outcomes in both study and control group post-intervention throughout and the end of pregnancy journey.

Planning phase:
Based on the findings acquired during assessment phase, the researchers developed an educational program regarding climate change and heat stress in the form of printed booklet, specially designed for pregnant women in simple Arabic language to accommodate their level of education and to satisfy the studied pregnant women's deficit knowledge and health-related behaviors regarding climate change. The number of sessions and its contents, as well as the methods of teaching, and instructional media were carefully determined. The objectives were formulated to be attained after completion of tailored educational program. The general objective was: by the end of the tailored educational program sessions, each woman will be able to acquire essential knowledge and health-related behaviors regarding climate change and heat stress needed to reduce adverse pregnancy outcomes.

Implementation phase
For study group, the researcher developed the tailored educational program to evaluate knowledge and health-related behaviors toward climate changes and heat stress among pregnant women working outdoors. This intervention was implemented through a series of three scheduled sessions, which took place in the waiting area of the outpatient clinic at Benha University hospital immediately after completion of the assessment phase. The duration of each session varied between 30 and 40 minutes, depending on the participants' progress and feedback. At the beginning of the first session the pregnant women were oriented with the contents of the intervention. Subsequent session started with a review of the previous session's outcomes and an outline the objectives of the new session. Simple Arabic language was used to suit women's level of understanding. At the conclusion of each session, five minutes were allocated for the women to ask questions and seek clarification on the content covered, in order to correct any misunderstanding. Each woman was informed about the timing of the next sessions.
Different methods of teaching were used such as lectures, critical thinking, and group discussions. The instructional media provided to all recruited women in the study consisted of booklets, which were distributed starting from the first session in order to fulfill the research objectives. Furthermore, the researchers utilized supportive tools that function as stimuli to facilitate the desired changes. These tools included stickers and flyers that reinforced the intervention's concepts and emphasizing the effects of the tailored educational program on women's knowledge, health-related behaviors regarding climate change and heat stress and climate change-related adverse pregnancy outcomes.
The **first session** was about climate changes such as (concept of climate change, causes, gases that cause climate change, images of climate change, psychological impact of climate change on the health of pregnant women, Physical impact of climate change on the health of pregnant women, People most affected by climate change and individual measures to limit climate change)
The **second session** was about heat stress such as (definition of heat stress, symptoms, causes, high risk persons, complications and management) and its effect on pregnant women such as (anemia, preterm birth, gestational hypertension, intrauterine growth retardation, antepartum hemorrhage, antepartum fetal distress, hyperemesis gravidarum, recurrent infections, altered nutritional composition, low birth weight, sleep deprivation and reduced quality of sleep, increased emergency hospital admission, fatigue and exhaustion and psychological anxiety and stress).
The **third session** was about health-related behaviors regarding climate change and heat stress and its effect on pregnancy outcomes.

Evaluation phase:
For study group, the effectiveness of the tailored educational program was evaluated after implementation using the same format of tools (Tool II & Tool III) which used during the assessment phase and the researchers evaluate women's knowledge and health-related behaviors one-month post-intervention from the last session and during outpatient follow up or via telephone in case of late. While, (tool IV): Adverse pregnancy outcomes questionnaire was evaluated in both study and control group after intervention till the end of pregnancy journey.
For control group, the studied women of control group received routine antenatal care, didn't receive tailored education program by the researchers and were followed and evaluated as the same in the study group.

Statistical analysis:
Data were verified prior to computerized entry. The collected data will be arranged, encoded, computerized and analyzed by using appropriate statistical methods and tests. The Statistical Package for Social Sciences (SPSS version 22.0) was utilized. Descriptive statistics encompassed frequencies and percentages, means, and standard deviations. The

study hypothesis was tested using inferential statistics such as the Chi-square test and independent t test. The correlation coefficient was used to investigate the relationship between knowledge scores and health-related behaviors. For all of the statistical tests done, p-value > 0.05 indicated no statistically significant difference, p-value ≤0.05 indicated a statistically significant difference, and p-value P ≤ 0.001 indicated a highly statistically significant difference.

Limitations

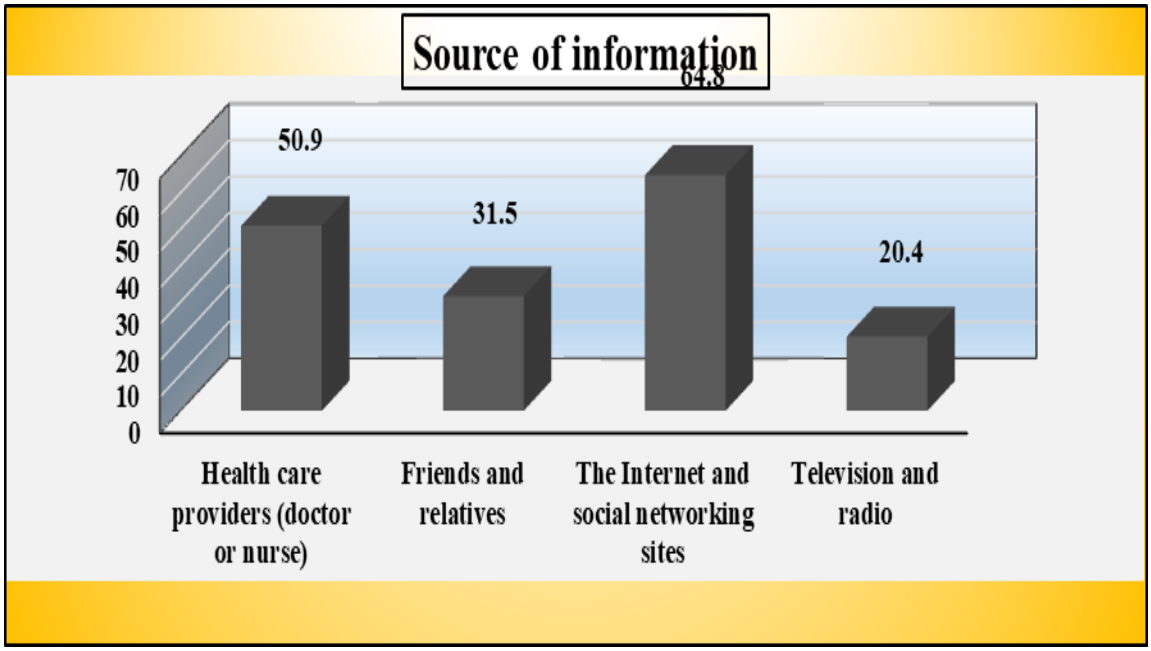
Occasionally, the antenatal clinic's waiting room may be crowded and noisy. Consequently, the researchers may endure substantial periods of times until the room becomes quiet and empty, thereby commencing the educational sessions and facilitating an environment of ease for the pregnant women. Furthermore, a number of women failed to consistently attend the educational sessions which necessitated calling them by telephone to remind them of appointments.

Results

Table (1): Distribution of the studied women (control and study group) according to their general characteristics (n=108).

Group General characteristics	Control group n=54		Study group n=54		X^2	p-value
	No	%	No	%		
Age						
18- < 25	10	18.5	7	13.0	1.45	0.484
25 - < 35	31	57.4	37	68.5		
≥35	13	24.1	10	18.5		
Mean ±SD	25.80 ± 3.43		24.18 ± 1.63			
Residence						
Rural	28	51.9	35	64.8	1.86	0.127
Urban	26	48.1	19	35.2		
Level of educational						
Read and write	8	14.8	10	18.5	0.476	0.924
Basic education	10	18.5	10	18.5		
Secondary education	22	40.8	19	35.2		
University education	14	25.9	15	27.8		
Income						
Sufficient	5	9.2	9	16.6	1.32	0.516
Fairly sufficient	30	55.6	28	51.9		
Insufficient	19	35.2	17	31.5		

**A Statistical significant p ≤ 0.05* ***A Highly Statistical significant p ≤ 0.001*



** Results not mutually exclusive*

Figure (1): Distribution of the studied women's source of information regarding climate changes and heat stress in both study and control groups (n =108).

Table (2): Distribution of the studied women (control and study) groups according to their obstetrical history (n=108).

Obstetrical history	Control group n=54		Study group n=54		X^2	p-value
	No	%	No	%		
Gravida						
Primigravida	15	27.8	20	37.0	1.05	0.304
Multigravida	39	72.2	34	63.0		
Parity						
Nulliparous	14	25.9	18	33.3	0.732	0.693
Primipara	16	29.6	15	27.8		
Multipara	24	44.5	21	38.9		
Current gestational age						
1st trimester	22	40.7	19	35.2	0.354	0.552
2nd trimester	32	59.3	35	64.8		
Mean ±SD	21.19 ± 1.84		22.00 ± 1.91		**t**=2.25	0.737

**A Statistical significant p ≤ 0.05* ***A Highly Statistical significant p ≤ 0.001*

Table (3): Distribution of the studied women according to their knowledge regarding climate changes in both study and control groups before and after intervention (n=108).

Knowledge items	Before intervention								X^2	p-value	After intervention								X^2	p-value
	Control group n=54				Study group n=54						Control group n=54				Study group n=54					
	Correct answer		Incorrect answer		Correct answer		Incorrect answer				Correct answer		Incorrect answer		Correct answer		Incorrect answer			
	No	%	No	%	No	%	No	%			No	%	No	%	No	%	No	%		
Concept of climate changes:	15	27.8	39	72.2	17	31.5	37	68.5	**0.178**	**0.673**	16	29.6	38	70.4	37	68.5	17	31.5	**16.33**	**0.000****
Causes of climate changes:	6	11.1	48	88.9	8	14.8	46	85.2	**0.328**	**0.567**	9	16.7	45	83.3	33	61.1	21	38.9	**22.44**	**0.000****
Gases that cause climate change	7	13.0	47	87.0	12	22.2	42	77.8	**1.59**	**0.206**	10	18.5	44	81.5	34	63.0	20	37.0	**22.09**	**0.000****
Images in which of climate change appear	21	38.9	33	61.1	24	44.4	30	55.6	**0.343**	**0.558**	22	40.7	32	59.3	49	90.7	5	9.3	**29.97**	**0.000****
Psychological impact of climate change on the health of pregnant women	13	24.1	41	75.9	12	22.2	42	77.8	**0.052**	**0.820**	12	22.2	42	77.8	36	66.7	18	33.3	**21.60**	**0.000****
Physical impact of climate change on the health of pregnant women	12	22.2	42	77.8	7	13.0	47	87.0	**1.59**	**0.206**	13	24.1	41	75.9	34	63.0	20	37.0	**16.61**	**0.000****
Adverse effect of climate change on the health of fetuses	10	18.5	44	81.5	9	16.7	45	83.3	**0.064**	**0.800**	11	20.4	43	79.6	35	64.8	19	35.2	**21.81**	**0.000****
People most affected by climate change	16	29.6	38	70.4	17	31.5	37	68.5	**0.044**	**0.835**	19	35.2	35	64.8	45	83.3	9	16.7	**25.92**	**0.000****
Individual measures to limit climate change	14	25.9	40	74.1	12	22.2	42	77.8	**0.203**	**0.653**	15	27.8	39	72.2	35	64.8	19	35.2	**14.89**	**0.000****

**A Statistical significant p ≤ 0.05* ***A Highly Statistical significant p ≤ 0.001*

Table (4): Distribution of the studied women according to their knowledge regarding heat stress in both study and control groups before and after intervention (n=108).

Knowledge items	Before intervention								X^2	p-value	After intervention								X^2	p-value
	Control group n=54				Study group n=54						Control group n=54				Study group n=54					
	Correct answer		Incorrect answer		Correct answer		Incorrect answer				Correct answer		Incorrect answer		Correct answer		Incorrect answer			
	No	%	No	%	No	%	No	%			No	%	No	%	No	%	No	%		
Concept of heat stress	20	37.0	34	63.0	22	40.7	32	59.3	**0.156**	**0.693**	20	37.0	34	63.0	47	87.0	7	13.0	**28.66**	**0.000****
Causes of heat stress	17	31.5	37	68.5	13	24.1	41	75.9	**0.738**	**0.390**	17	31.5	37	68.5	48	88.9	6	11.1	**37.13**	**0.000****
Symptoms of heat stress	15	27.8	39	72.2	17	31.5	37	68.5	**0.178**	**0.673**	16	29.6	38	70.4	36	66.7	18	33.3	**14.83**	**0.000****
Diagnosis of heat stress	13	24.1	41	75.9	12	22.2	42	77.8	**0.052**	**0.820**	14	25.9	40	74.1	38	70.4	16	29.6	**21.36**	**0.000****
Complications of heat stress	12	22.2	42	77.8	14	25.9	40	74.1	**0.203**	**0.653**	12	22.2	42	77.8	31	57.4	23	42.6	**13.94**	**0.000****
Ways to prevent exposure to heat stress	16	29.6	38	70.4	14	25.9	40	74.1	**0.185**	**0.677**	16	29.6	38	70.4	39	72.2	15	27.8	**19.59**	**0.000****
Ways to overcome heat stress related to climate change	14	25.9	40	74.1	12	22.2	42	77.8	**0.203**	**0.653**	14	25.9	40	74.1	37	68.5	17	31.5	**19.65**	**0.000****

**A Statistical significant p ≤ 0.05* ***A Highly Statistical significant p ≤ 0.001*

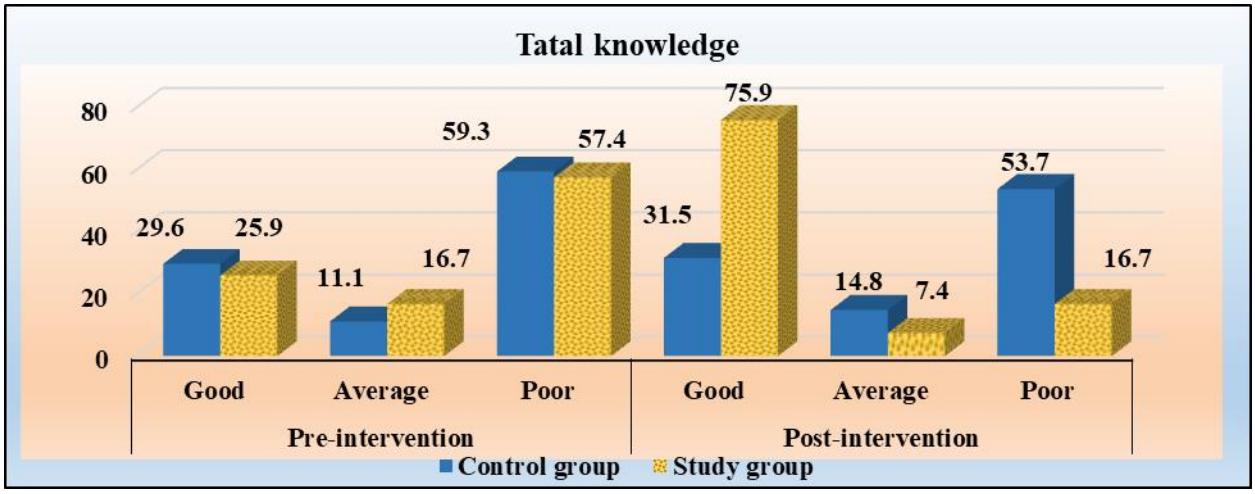


Figure (2): Distribution of the studied women's total knowledge regarding climate changes and heat stress in both study and control groups before and after intervention (n =108).

Table (5): Total mean scores of health-related behaviors domains of the studied women regarding climate changes in both study and control groups before and after intervention (n=108).

Health-related behaviors subscales		No. of items	Maximum score	Control group n=54 Mean ± SD	Study group n=54 Mean ± SD	Independent t-test	P-value
General measures	Before intervention	6	18	12.40±3.02	11.64±3.13	1.281	0.203
	After intervention			12.63±2.98	15.3±1.70	5.864	0.000**
Nutritional practices	Before intervention	4	12	8.33±1.50	8.61±1.48	9.66	0.366
	After intervention			8.67±1.37	10.56±1.31	7.305	0.000**
Clothes and protective tools	Before intervention	6	18	11.83±3.02	11.59±2.98	0.416	0.678
	After intervention			12.15±2.62	15.91±1.48	9.167	0.000**
Daily activities and sports	Before intervention	8	24	11.83±1.99	11.66±1.75	0.460	0.646
	After intervention			12.04±1.90	18.91±2.53	15.92	0.000**
Resorting to medical care	Before intervention	2	6	2.88±1.14	3.20±0.87	1.605	0.111
	After intervention			3.30±1.05	4.54±0.79	6.895	0.000**
Total score	Before intervention	26	78	47.29±5.31	46.72±5.69	0.542	
	After intervention			48.77±4.68	65.27±4.18	19.28	0.000**

**A Statistical significant p ≤ 0.05* ***A Highly Statistical significant p ≤ 0.001*

Table (6): Total mean scores of health-related behaviors domains of the studied women regarding heat stress in both study and control groups before and after intervention (n=108).

Health-related behaviors subscales		No. of items	Maximum score	Control group n=54 Mean ± SD	Study group n=54 Mean ± SD	Independent t-test	P-value
Measures in case of sunstroke	Before intervention	4	12	4.24±1.62	4.16±1.63	0.236	0.814
	After intervention			5.02±2.22	9.22±1.34	11.88	0.000**
Measures in case of heat exhaustion	Before intervention	4	12	6.27±1.35	6.62±1.15	1.455	0.149
	After intervention			6.56±1.35	10.93±0.72	20.90	0.000**
Measures in case of sun burn	Before intervention	7	21	11.66±1.95	11.40±1.66	0.742	0.459
	After intervention			11.67±1.95	16.54±2.87	10..30	0.000**
Measures to avoid heat cramps	Before intervention	4	12	5.14±0.93	4.87±0.97	0.539	0.134
	After intervention			5.22±1.02	11.26±0.70	35.73	0.000**
Measures to avoid heat rash	Before intervention	5	15	9.77±2.22	9.85±2.00	0.182	0.856
	After intervention			10.13±1.90	12.96±1.02	9.625	0.000**
Total score	Before intervention	24	72	37.11±3.23	36.92±3.28	0.295	0.768
	After intervention			38.59±3.53	60.90±4.34	29.28	0.000**

**A Statistical significant p ≤ 0.05* ***A Highly Statistical significant p ≤ 0.*

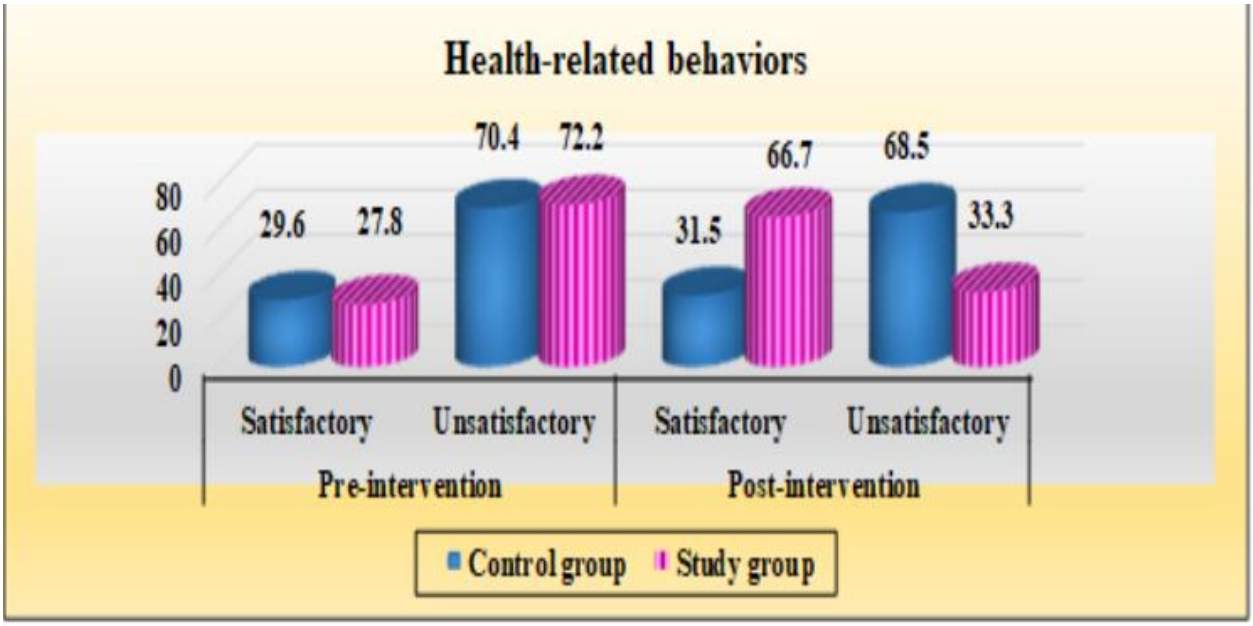


Figure (3): Distribution of the studied women total health-related behaviors regarding climate changes and heat stress in both study and control groups before and after intervention (n =108).

Table (7): Distribution of the studied women regarding their adverse pregnancy outcomes resulting from climate changes and heat stress in both study and control groups after intervention (n=108).

Adverse pregnancy outcomes		Control group n=54		Study group n=54		X^2	P-value
		No	%	No	%		
Anemia		24	44.4	14	25.9	**4.06**	**0.044***
Preterm birth		10	18.5	3	5.6	**4.28**	**0.038***
Gestational hypertension		7	7.4	1	3.7	**4.86**	**0.027***
Intrauterine growth retardation		6	11.1	1	1.9	**3.81**	**0.050***
Antepartum hemorrhage		4	7.4	0	0.0	**4.15**	**0.042***
Antepartum fetal distress		4	7.4	2	3.7	**7.05**	**0.401**
Hyperemesis Gravidarum		2	3.7	1	1.9	**0.343**	**0.558**
Recurrent infections		12	26.7	3	5.6	**6.27**	**0.012***
Altered nutritional composition		11	20.4	3	5.6	**5.25**	**0.022***
Low birth weight		13	24.1	5	9.3	**4.26**	**0.039***
Sleep deprivation and reduced quality of sleep	Mild deprivation	35	64.8	48	88.9	**11.50**	**0.003***
	Moderate deprivation	11	20.4	6	11.1		
	Severe deprivation	8	14.8	0	0.0		
Increased emergency hospital admission		15	27.8	4	7.4	**7.72**	**0.005***
Fatigue and exhaustion	Mild	21	38.9	40	74.1	**14.37**	**0.001****
	Moderate	24	44.4	12	22.2		
	Severe	9	16.7	2	3.7		
Psychological anxiety and stress	Mild	39	72.2	50	92.6	**7.94**	**0.019***
	Moderate	13	24.1	3	5.6		
	Severe	2	3.7	1	1.9		

≠ *Not mutually exclusive* **A statistical significant p ≤ 0.05* ***A Highly statistical significant p ≤ 0.001*

Table (8): Correlation coefficient between total knowledge scores and health-related behaviors of studied women in both study and control groups before and after intervention (n =108).

Variables	Total Knowledge							
	Control group n=54				Study group n=54			
	Before intervention		After intervention		Before intervention		After intervention	
	r	p-value	R	p-value	r	p-value	R	p-value
Total health-related behaviors	0.643	**0.000****	0.590	**0.000****	0.551	**0.000****	0.492	**0.000****

***A Highly Statistical significant p ≤ 0.001*

Table (1): Demonstrates that, 68.5% of the study group and 57.4% of the control group were aged within the 25-< 35 years old with a mean age of 24.18 ± 1.63 years and 25.80 ± 3.43 years respectively. In terms of residence, more than two third (64.8%) of the study group and more than half (51.9%) of control group were lived in rural area. Regarding educational level, 35.2% of the study group and 40.8% of the control group had secondary education. As far as monthly income, more than half of both groups (51.9% and 55.6% respectively) had fairly sufficient income. It is important to note that no statistically significant difference was detected between the two groups in terms of general characteristics' data, indicating that the study groups were comparable and homogeneous.

Figure (1): Illustrates that, (64.8%) (50.9%) (31.5%) of studied women obtain their information from internet and social media, health care provider and friends & relatives respectively.

Table (2): Reveals that, (63.0% and 72.2%) of the studied women in both study and control group were multigravida, respectively. In relation to parity, it was observed that 38.9% of the study group and 44.5% of the control group were multipara. Furthermore, the mean gestational age of both groups was 22.00 ± 1.91 and 21.19 ± 1.84 weeks, respectively.

Table (3): Shows that, there was no statistically significant difference observed between the women in the study and control groups in terms of their knowledge about climate changes before

implementation of the tailored education program (P>0.05). Conversely, there was a highly statistically significant difference between both groups with regards to their knowledge after implementation of the tailored education program (P< 0.001). The women in the study group exhibited a higher percentage of knowledge scores compared to those in the control group.

Table (4): Eaborates that, there was no statistically significant difference observed between studied women of study and control groups in terms of their knowledge about heat stress before the implementation of the tailored education program (P>0.05). However, it is important to note that after the tailored education program was implemented, a highly statistically significant difference was observed between both groups in terms of their knowledge (P< 0.001). In fact, the women in the study group displayed a higher percentage of knowledge score compared to those in the control group.

Figure (2): Demonstrates that, (25.9%) of study group and (29.6%) of control group had good knowledge regarding climate changes and heat stress before implementation of the tailored education program. In contrast, after the implementation of tailored education program, a significantly higher percentage of the study group (75.9%) exhibited good knowledge in comparison to the control group (31.5%).

Table (5): Shows that, before implementation of the tailored education program, the mean scores of total health-related behaviors shows shows the study and control groups (46.72±5.69 and 47.29±5.31, respectively), with no statistical significance difference observed (P>0.05). However, after implementation of the tailored education program, the mean difference score for total health-related behaviors in the study group was higher compared to the score in the control group (65.27±4.18 versus 48.77±4.68, respectively), with a highly statistically significant difference (P≤ 0.001). Such significant differences also existed in all subscales of health-related behaviors, including general measures, nutritional practices, clothes and protective tools, and resorting to medical care ($p \leq 0.001$).

Table (6): Displays that, before implementation of the tailored education program, the mean scores of total health-related behaviors regarding heat stress indicated impaired health-related behaviors in both the study and control groups (25.51±3.14 and 25.44±3.19, respectively), with no statistically significant difference (P>0.05). However, after implementation of the tailored education program, the mean difference score for total health-related behaviors in the study group was higher than the score in the control group (44.37±2.18 versus 26.92±3.32, respectively) with a highly statistically significant difference (P≤ 0.001). Such significant differences were also evident in all subscales of health-related behaviors, encompassing measures in case of sunstroke, measures in case of heat exhaustion, measures in case of sun burn, measures to avoid heat cramps, and measures to avoid heat rash ($p \leq 0.001$).

Figure (3): Illustrated that, before the implementation of the tailored education program, a satisfactory level of health-related behaviors regarding climate changes and heat stress was reported by 27.8% of women in the study group and 29.6% of women in the control group. In contrast, after implementation of the tailored education program, a higher proportion of women in study group (66.7%) exhibited satisfactory level of health-related behaviors compared to (31.5%) of the control group.

Table (7): Shows that, there is a statistically significant difference between study and control groups regarding adverse pregnancy outcomes as anemia, preterm birth, gestational hypertension, intrauterine growth retardation, ante partum hemorrhage, recurrent infections, altered nutritional composition, low birth weight, sleep deprivation and reduced quality of sleep, increased emergency hospital admission and psychological anxiety and stress. Moreover, there was a highly statistically significant difference was observed between study and control groups in levels of fatigue and exhaustion. Conversely, no statistically significant difference was noted between study and control group regarding antepartum fetal distress and hyperemesis gravidarum.

Table (8): Reveled that, there was a highly positive statistical correlation between total knowledge and total health-related behaviours scores of studied women in both the study and control groups before and after intervention ($p \leq 0.001$) (this means that; as knowledge increases, health-related behaviours also increases, and vice versa).

Discussion

Climate change refers to the alteration of weather conditions and the overall temperature around the world and its effect on human, animal and plant life. The primary causes of climate change is the elevation of temperatures worldwide, primarily attributed to the release of greenhouse gases resulting from the combustion of fossil fuels, such as carbon dioxide and methane **(Liverpool et al.,, 2023).**

Climate change poses the greatest health hazard to humanity, and has led health professionals worldwide to take action against the health risks

arising from this unfolding crisis. Pregnant women are particularly susceptible to unfavourable environmental conditions **(Kasimanickam & Kasimanickam, 2021)**. Elevated ambient temperatures resulting in heat stress can have adverse pregnancy outcomes, such as preterm birth, stillbirth and low fetal weight. The impact of heat stress extends to the disruption of hormonal balance. This disruption may be responsible for the threat posed by heat stress to the successful progression of pregnancy and fetal development **(Adur et al., 2022).**

The aim of the current research was to investigate the effectiveness of tailored educational program on knowledge and health-related behaviours toward climate changes and heat stress among pregnant women working outdoors. The research findings significantly supported the research hypotheses, which prove the significance of utilizing the tailored educational program and instructional booklet to enhance women's knowledge and health-related behaviors toward climate changes and heat stress among pregnant women working outdoors, and its importance in reducing adverse pregnancy outcomes.

Regarding general characteristics of the studied women, the present research results cleared that, more than two-thirds of study group and more than half control groups respectively were between the ages of 25 - < 35 years old with a mean age of 24.18 ± 1.63 years and 25.80 ± 3.43 years, respectively. Pertaining to the place of residence, less than two-thirds of the study group and more than half of control group were lived in rural area, more than one-third study group and more than two-fifths of control groups, respectively had secondary level of education. In terms of monthly income, more than half of both groups possessed an adequately satisfactory income. There was no statistically significant difference observed between both groups pertaining to general characteristics, which mean that the two groups under study displayed remarkable homogeneity. From the researchers' point of view, low educational of women level and the rural residence may be the reason for their lack of knowledge and healthy behavior towards climate changes and heat stress.

This result was in agreement with **Abd-Elhamed et al., (2023)** who reported that there were no statistically significant differences between participants in both groups regarding their age, residence, occupation and education where p-value was 0.351, 0.151, 0.313, and 0.210 respectively. Moreover, **Eltelt et al., (2023)** mentioned that the mean age of studied participants was 19.83±7.34. Pertaining to the residence, about three quarter of them was lived in rural area. Additionally, educational levels, less than half and less than one quarter read and write and had secondary education respectively.

Pertaining to source of information, it was displayed that, the majority of studied women (less than two-thirds), (more than half) and (less than one-third) obtain their information from internet and social media, health care provider and friends &relatives respectively. This result was similar to **Mahmoud et al., (2023)** who found that social media is the most common source of information for nearly half of participants followed by television which is reported by more than one third of participants. These findings emphasized the notable impact of internet and social media on the knowledge and behaviors of pregnant women, both in a positive and negative manner. Consequently, it is crucial that educational programs equip pregnant women with the necessary information and best practices.

As regards obstetrical history, the findings of current research indicated that, (less than two-thirds and less than three-quarters) of the studied women in both study and control group were multigravida, respectively. In relation to parity, (less than two-thirds) of the study group and (more than two-fifths) of the control group were multipara. Moreover, the mean gestational age of the study and control groups was 22.00±1.91 and 21.19±1.84 weeks, respectively.

The current findings of this research are in concordance with **Abd-Elhamed et al., (2023)** who cleared that there were no statistically significant differences between participants in both groups regarding their gravidity, mode of previous birth, history of abortion & in what season of the year it happens, as well the gestational age of the current pregnancy, where P-value were 0.138, 0.499, 0.899, and 0.546 respectively. However, the same table displayed that there was a statistically significant differences between participants in both groups and their parity as P-value equal 0.012.

Regarding knowledge of studied women, the findings of the present research revealed that there was no statistically significant difference in the level of knowledge pertaining to climate changes and heat stress between studied women in both the study group and control group before implementation of the tailored educational program (P>0.05). Conversely, a highly statistical significant difference was observed between both groups in terms of their knowledge after implementation of the tailored educational program (P<0.001), as the study group exhibited a greater percentage of knowledge score compared to the control group. It is noteworthy that a considerable proportion of the study group (more than quarter) and a lesser proportion of the control group (less than one-third) had good knowledge concerning climate changes and heat stress before

implementation of the tailored educational program. However, after implementation of tailored educational program, a significantly larger proportion of the study group (more than three-quarters) had good knowledge in comparison to the control group (less than one-third). This finding can be attributed to the positive impact of the tailored educational program and the well- structured educational sessions. The topic of the study was deemed important and sensitive to the women involved in the study, thereby resulting in their high level of interest and satisfaction during the learning sessions. Additionally, an instruction booklet was given to the women in an attempt to reduce any potential risks to the mother and the fetus.

Increasing, the finding of current research aligned with those of the previous study done by **Eltelt et al., (2023)** who found that, less than two third of studied sample had poor knowledge regarding climate changes and heat stress, less than one third of studied sample had average knowledge, while nearly one tens of them had good knowledge. Also, this result was in accordance with **Mahmoud et al., (2023)** who illustrated that general knowledge about climate change was fair in about two thirds of studied sample. In assessing their knowledge about the potential impacts of climate change on women's health, it was found that more than one third of them have good knowledge. However, the mean score of the overall knowledge is 36.40±7.84 with a total percent score of 62.77% indicating fair knowledge.

In addition, **Abd-Elhamed et al., (2023)** supported current research findings when indicated that the comparison between the women's knowledge levels during the pre and post intervention among the narrative and did active group. It is clear that the women's level of knowledge was similar between the two groups in the pre-intervention test, with poor level as the percentage was about more one third among the studied groups. While a clear improvement appeared in the women's level of knowledge in the post intervention test as the narrative group represented good level of knowledge with more than two third compared to the deductive group, which documented only less than one tens with a statistically significant differences between participants among both groups after implementation of the intervention as P-value was <0.001.

Furthermore, the finding of present research was consistent with the study done by **Adebayo et al., (2020)** indicated that the educational intervention could potentially possess significance beyond improving pregnant women's knowledge and reducing climate change-related risks during pregnancy.

Concerning women's health-related behaviors, the current research findings elaborated that, before the implementation of the tailored educational program, the mean scores of total health-related behaviors regarding climate changes and heat stress indicated impaired health-related behaviors in both the study and control groups (46.72±5.69 and 47.29±5.31, respectively), with no statistically significant difference (P>0.05). However, after the implementation of the tailored educational program, the mean difference score for total health-related behaviors in the study group was higher than the score in the control group (65.27±4.18 versus 48.77±4.68, respectively), with a highly statistically significant difference (P≤ 0.001). These significant differences were also observed in all subscales of health-related behaviors regarding climate changes, including general measures, nutritional practices, clothing and protective tools, and seeking medical care ($p \leq 0.001$).

Similarly, significant differences were observed in all subscales of health-related behaviors to heat stress, including measures in case of sunstroke, measures in case of heat exhaustion, measures in case of sunburn, measures to prevent heat cramps, and measures to prevent heat rash ($p \leq 0.001$). Moreover, it was determined that, more than quarter of study group and (less than one-third) of the control group exhibited a satisfactory level of health-related behaviors regarding climate changes and heat stress before implementation of the tailored educational program. Conversely, after the implementation of the tailored educational program, (two-thirds) of the study group had satisfactory level of health-related behaviors compared with (less than one-third) of the control group.

This enhancement in the women's health-related behaviours could potentially be attributed to permitted discussion for women and effective communication during the educational sessions with the researchers who facilitated their acquisition of knowledge about healthy behaviours. Furthermore, the instructional booklet played a vital role in assisting women to acquiring healthful behaviours and utilizing it as a point of reference in the future

This result was in agreement with **Mahmoud et al., (2023)** who reported that the overall practices were unsatisfactory in the majority of study participants with a mean score of 8.76±2.65. As well as, **Ghazy &Fathy, (2023)** noticed that improving in most aspects of studied sample's daily life reported practices. Moreover, total practices of them revealed that the majority of study participants had good practices after the implementation of program compared to less than one quarter before program with highly statistical significant difference between

pre-test and post-test phase (p <0.000). Furthermore, **Talavera et al., (2020)** indicated that, half of the participants exhibited a moderate level of practices related to climate change.

The present research finding cleared negative consequences of climate changes and heat stress on occurrence of adverse pregnancy outcomes; pertaining to this, our research results findings indicated that a statistically significant difference existed between the study and control groups regarding adverse pregnancy outcomes as anaemia, preterm birth, gestational hypertension, intrauterine growth retardation, ante partum haemorrhage, recurrent infections, altered nutritional composition, low birth weight, sleep deprivation and reduced quality of sleep, increased emergency hospital admission and psychological anxiety and stress. Furthermore, a highly statistically significant difference was observed between the study and control groups in terms of fatigue and exhaustion levels. Conversely, no statistically significant difference was found between the study and control group regarding ante partum fetal distress and hyperemesis gravidarum. This significant difference between control and study groups regarding negative consequences of climate changes and heat stress on occurrence of adverse pregnancy outcomes mirrored the effect of the tailored educational programs.

From the researchers' view of point view, climate change adaptation interventions through the educational programs are essential to limit the current and anticipated effects of climate change on maternal and fetal health. It is crucial to actively involve pregnant women in the design and implementation of adaptation interventions to enhance their efficacy and acceptance.

These findings were supported by **United States Environmental Protection Agency, (2022)** which revealed that certain health problems including anemia, eclampsia, low birth weight, preterm birth, miscarriage, and psychological stress, have been associated with climate-related hazards, such as extreme heat, flooding, and wildfires.

In the same context, **Yüzen et al., (2023)** highlighted the multifaceted implications of heat stress on the balance of hormones and the stability of the immune system, particularly during pregnancy. The direct impact of heat exposure on the thermoregulation of pregnant women leads to cellular stress, subsequently causing disruptions in endocrine and immunological functions. Moreover, heat stress acts as an external stressor, which activates the internal stress response, initiating a cascade of hormonal reactions. These changes can ultimately lead to adverse pregnancy outcomes, such as, preterm birth, stillbirth and low fetal weight.

Also, the present research results were supported by **Morris, (2022)** who concluded that there exists a correlation between climate change and adverse pregnancy outcomes, including low birth weight, preterm labor, stillbirth, impaired growth and development caused by maternal malnutrition, repeated infection and limited psychosocial stimulation . Also, **Ha, (2022)** reported that the changing climate has a direct impact on the health of pregnancies through discrete environmental disasters, such as wildfire, extreme heat, hurricane, flood, and droughts. Additionally, these climate-related disasters indirectly affect pregnancy health by altering both the natural and social environment. The occurrence of climate-related disasters is linked to an elevated risk of complications during gestation, pregnancy loss, restricted fetal development, low birth weight, preterm birth, and certain delivery/newborn complications.

Also, this result was in accordance with **Chersich et al., (2020)** who clarified that exposures to high temperature during pregnancy is associated with adverse birth outcomes, particularly preterm birth and stillbirth, as evidenced by consistent findings and significant effect sizes.. This comprehensive review emphasizes the urgent need to develop interventions that target heat-related conditions in pregnant women, particularly those in extreme age groups and lower socioeconomic backgrounds, and to assess their efficacy. In a related context, **the Western States Pediatric Environmental Health Specialty Unit (WSPEHSU), (2022)** has reported that pregnant women are particularly susceptible to the health consequences of climate change, with an elevated risk of experiencing adverse pregnancy complications such as preterm birth, small for gestational age, and hypertensive disorders of pregnancy.

Pertaining to correlation between knowledge and health-related behaviors, the present research results clarified that there was a highly positive statistical correlation between total knowledge and total health-related behaviors scores of studied women in both groups before and after intervention ($p \leq 0.001$) (this means that; with an increase in knowledge, there is a concurrent increase in health-related behaviors, and vice versa). This finding demonstrated consistency with the findings of **Mahmoud et al., (2023)** who revealed that knowledge and practices were positively correlated. A statistically significant difference was found between overall knowledge score and overall practices score ($r = 0.220$, $P = <0.001$). Additionally, **Ghazy & Fathy, (2023)** agreed to somewhat with current research results and reflected that there was a highly positive correlation ($r = .980$ & $r = .839$) at $p < 0.001$ between the post-

program total knowledge score level and total daily life practices & attitudes, no relationship was observed in the preprogram phase.

Increasing, our research findings matched with **Abd-Elhamed et al., (2023)** who illustrated that a clear positive correlation between the level of knowledge and perception of women in both groups. Importantly, the disparities among the participants in the two groups were statistically significant among the narrative group and their perception which related to women's knowledge as P-value was 0.003 &<0.001 respectively

As well as, the present research findings align with the results reported by **Talavera et al., (2020)** who mentioned that the association is significant between knowledge and practice with r values of 0.016. As well as, **Eltelt et al., (2023)** demonstrated a highly positive statistical correlation between total knowledge and total reported practices scores of studied sample in relation to climate changes and heat stress. This finding demonstrated the relationships between these two domains of learning and emphasizes the importance of incorporating them into educational programs for pregnant women.

Conclusion

Based on the current research findings; it was concluded that the research hypotheses were supported and the tailored educational program sessions had a positive effect on enhancement knowledge and health-related behaviors of pregnant women towered climate changes and heat stress in the study group, in comparison to the control group. Additionally, there was a statistically significant difference between the study and control groups regarding adverse pregnancy outcomes favoring the study group. Moreover, in both the control and study groups; there was a highly positive statistical correlation between total knowledge and total health-related behaviors scores of studied women before and after the intervention. Therefore, the effect of tailored educational program was reflected.

Recommendations

Based on the current research findings, the following recommendations were suggested:

- Dissemination of the current research tailored educational program to all antenatal clinics and maternity hospitals at Benha city.
- Establishing and maintaining effective antenatal care in the face of harsh life circumstances through new educational interventions to lessen the detrimental effects on maternal and fetal health which brought on by the climate changes conditions.
- Using social media platforms to enhance the pregnant women's knowledge and foster their healthy behaviors concerning climate change.
- Conducting educational programs and training workshops to enhance nurse's awareness of climate change and its impacts on pregnant women's health and their fetuses.
- **Further research** is needed to increase pregnant women's knowledge of how climate change and its environmental consequences affect the health of pregnant women and their fetuses.

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