RESEARCH ARTICLE

# Physical environment and blood glucose level of diabetic patients: A cross-sectional study

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## Abstract

**Objective:** To determine the correlation between physical environment and blood glucose levels in diabetic patients.

**Method:** The quantitative, cross-sectional study was conducted from July to October 2022 at the Rejosari Pekanbaru Community Health Centre, Indonesia, and comprised diabetic patients of either gender with a disease history of at least 3 years. Environmental temperature was considered acceptable at 18-20°C, while environmental light was considered acceptable at 60-120 lux. Random blood glucose level <60mg/dL was taken as low, 70-130 mg/dL normal, and >140 mg/dL high. The correlation between physical environment and blood glucose level was worked out. Data was analysed using SPSS 20.

**Results:** Of the 125 subjects, 89(71.2%) were females and 36(28.8%) were males. There were 45 patients aged 56-65 years and 11(8.8%) were aged <11 years. Overall, 90(72%) patients had high random blood sugar and 35(28%) had normal level. The disease duration was <5 years in 79(63.2%) cases and >5 years in 46(36.8%). Of the 80(64%) patients who lived in an unacceptable living room temperature, 63(78.8%) had high random blood glucose levels ($p$=00042). Of the 73(58.4%) patients who lived in an unacceptable living room light, 59(80.8%) had high random blood glucose ($p$=0.016).

**Conclusion:** A significant effect of temperature and light was found on blood glucose levels in diabetic patients.

**Keywords:** Diabetes, Temperature, Light, Glucose. (JPMA 74: S-70 [Suppl. 5]; 2024)

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## Introduction

The physical environment, such as temperature and light, can affect body metabolism. Environmental factors can affect the incidence of diabetes mellitus (DM), such as exposure to environmental pollutants or the presence of environmental chemicals in the form of phthalates, bisphenol A, perfluorinated compounds, polychlorinated biphenyls (PCBs), dioxins and toxins that contribute to the development of DM through impaired pancreatic beta cell function and immune cells and immunomodulation, which is a way to restore and repair the immune system whose function is impaired or to suppress excessive function.[1]

Air pollution, residential noise, walking spaces within the neighbourhood are all strongly associated with DM development. In addition, the food environment, social aspects of the environment, temperature, lifestyle can influence the development of DM.[2] High indoor temperatures affect aspects of human health, with the strongest evidence for respiratory health and diabetes management. Inappropriate temperatures can affect DM management.[3]

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Temperature and light can increase blood glucose in diabetics by enhancing endogenous sugar production or decreasing tissue glucose uptake. Exposure to bright light can impact postprandial (post-meal) glucose metabolism, thermoregulation, and energy expenditure in insulin-resistant individuals.[4] Diabetic patients have problems with thermoregulation due to complications of autonomic neuropathy.

Thermal stress can present a challenge to homeostasis, especially for the cardiovascular system and glycaemia. Moreover, thermal stress can alter insulin absorption and diffusion properties as well as various counter-regulatory hormones that can greatly impact acute and even chronic glycaemia management.[5] Bright light increases glucose levels due to increased production of endogenous glucose or decreased tissue glucose uptake.

Natural or artificial lighting directly or indirectly can illuminate the entire room with an intensity of intensity of at least 60 lux and not dazzling to the eyes.[6] The current study was planned to determine the correlation between physical environment (temperature and light) and diabetic patients' blood glucose levels. During warm weather, it is very important for diabetics to stay well hydrated, in addition diabetics are asked to stay indoors and check blood sugar regularly for changes when the temperature starts to rise. Hot weather can increase the risk of hypoglycaemia for those taking blood glucose lowering medications.[7]

## Subjects and Methods

The quantitative, cross-sectional study was conducted from July to October 2022 at the Rejosari Pekanbaru Community Health Centre, Indonesia. After approval from the ethics review committee of the College of Health, Payung Negeri, Pekanbaru, the sample was calculated using the Slovin formula.[8] The sample was raised using purposive sampling technique from among the entire population of DM patients seeking treatment at the health centre.

Those included were adult DM patients of either gender with a disease history of at least 3 years. Those with hearing loss, and those unable to communicate effectively were excluded.

After taking informed consent from the participants, a thermo-hygrometer was used to measure environmental temperature that was categorised as acceptable in the range 18-20°C. A lux meter was used to determine environmental light with parameters 60-120 lux as qualified and <60 or >120 as unqualified. Random blood glucose (RBG) was assessed using a glucometer, and it was categorised as low <60mg/dL, normal 70-130mg/dL, and high >140 mg/dL. The instruments had certificate of calibration from the respective manufacturers. Manufactured data from Smart Sensor for Luxmeter: place and environmental condition of the calibration in Smart Sensor FQS, temperature 23°C-27°C, RH: 50% RH-75% RH, date 2021 Augustus 6. Meanwhile for Digital Thermometer, the manufactured from Metology Management Unit Indonesia with the following details: type HTC-2, capacity (-10~50)°C/0.1°C, series number 21-7951-01, date 2022 July 22.

Data regarding the subjects' home was also collected through observation, which is a complex process consisting of various biological and psychological processes. Observations were made regarding the physical environment; room temperature and room light. Room temperatures were captured by placing the thermo-hygrometer for 15 minutes in the centre of the room as it is believed to be homogenous. Room light was assessed by placing the lux meter 75 cm from the floor in the centre of the room from 11am to 4pm.

Data was analysed using SPSS 20. Chi-square test was used to examine the correlation between physical environment and RBG level. P<0.05 was considered statistically significant.

## Results

Of the 465 registered patients, 182(39.12%) were assessed, and 125(66.13%) of them were included; 89(71.2%) females and 36(28.8%) males. There were 45 patients aged 56-65

**Table-1:** Respondents' characteristics.

| Characteristics of respondents | n (%) |
|---|---|
| **Age** (years) | |
| ≤45 | 11 (8.8) |
| 46-55 | 37 (29.6) |
| 56-65 | 45 (36.0) |
| >65 | 32 (25.6) |
| **Gender** | |
| Male | 36 (28.8) |
| Female | 89 (71.2) |
| **Education Level** | |
| No School | 3 (2.4) |
| Elementary School | 11 (8.8) |
| Junior High School | 2 (1.6) |
| Senior High School | 73 (58.4) |
| Higher Education | 36 (28.8) |
| **Work** | |
| Civil servants | 4 (3.2) |
| Self employed | 14 (11.2) |
| Farmer | 2 (1.6) |
| Housewife | 72 (57.6) |
| Pensioner | 31 (24.8) |
| Labourer | 2 (1.6) |
| **DM duration** (years) | |
| ≥5 | 46 (36.8) |
| <5 | 79 (63.2) |
| **blood glucose Level** | |
| High | 90 (72.0) |
| Normal | 35 (28.0) |
| **Total** | 125 (100) |

DM: Diabetes mellitus.

**Table-2:** Random blood glucose (RBG) level.

| Random blood glucose | n (%) |
|---|---|
| High | 90 (72) |
| Normal Range | 35 (28) |
| **Total** | 125 (100) |

**Table-3:** Relationship between temperature and random blood glucose (RBG).

| Temperature | Random blood glucose | | Total | OR | *p*-value |
|---|---|---|---|---|---|
| | High | Normal | | | |
| | n (%) | n (%) | n (%) | | |
| **Living Room** | | | | 2.47 | 0.04 |
| Unacceptable | 63 (78.8) | 17 (21.2) | 80 (100) | | |
| Acceptable | 27 (60.0) | 18 (12.6) | 45 (100) | | |
| **Total** | 90 (72.0) | 35 (28.0) | 125 (100) | | |

OR: Odds ratio, DM: Diabetes mellitus.

**Table-4:** Relationship between light and random blood glucose (RBG).

| Light | Random blood glucose | | Total | OR | *p*-value |
|---|---|---|---|---|---|
| | High | Normal | | | |
| | n (%) | n (%) | n (%) | | |
| **Living Room** | | | | 2.855 | 0.01 |
| Unacceptable | 59 (80.8) | 14 (19.2) | 73 (100) | | |
| Acceptable | 31 (59.6) | 21 (40.4) | 52 (100) | | |
| Total | 90 (72.0) | 35 (28.0) | 125 (100) | | |

OR: Odds ratio, DM: Diabetes mellitus.

years and 11(8.8%) were aged <11 years. The disease duration was <5 years in 79(63.2%) cases and >5 years in 46(36.8%) (Table 1). Overall, 90(72%) patients had high RBG and 35(28%) had normal RBG levels (Table 2).

Of the 80(64%) patients who lived in an unacceptable living room temperature, 63(78.8%) had high RBG levels (*p*=00042) (Table 3). Of the 73(58.4%) patients who lived in an unacceptable living room light, 59(80.8%) had high RBG (*p*=0.016) (Table 4).

## Discussion

Diabetes incidence and prevalence of glucose intolerance increase with rising outdoor temperatures.[9] Temperature has a positive relationship with glucose metabolism and insulin resistance in adults.[10] Bright light exposure has been reported to be associated with increased glucose and triglyceride levels in type 2 DM.[11] Some diabetes patients had lower skin blood flow and sweating responses during heat exposure and this could have important consequences on cardiovascular regulation and glycaemic control. Those who are particularly vulnerable include individuals with poor glycaemic control and who are affected by diabetes-related complications.[5]

Riau Province is located on the equator. The temperatures in Riau province generally did not meet the acceptability requirement and were >30ºC. This relatively high temperature is also influenced by Pekanbaru's geographical location, which is in the tropics and crosses the equator. Regions crossed by the equator have a different climate compared to regions in the northern and southern hemispheres. Areas around the equator, such as Indonesia, have a tropical climate that is hot all year round.

Pekanbaru, a large port city in the Riau province of Indonesia, experiences a tropical rainforest climate. The weather is generally hot and humid throughout the year, with an average temperature of 27°C, ranging 34.1-35.6°C.[10]

In diabetics, high temperatures can cause dehydration, which can cause the blood glucose levels to rise. When fluid levels are low, the kidneys receive less blood flow, and function less effectively, which can lead to hyperglycaemia.[5] Hot weather may increase the risk of hypoglycaemia in people who take blood glucose-lowering medications.

Observations made by the researchers suggested that the respondents' home lighting was provided by natural light during the day. The poor lighting was caused by the location of the living room. The average lighting was too bright, which was because the windows were being kept open and sunlight was not being blocked with the help of curtains or shades. The lighting in other rooms was not as bright as it was in the living room, and some rooms had low lighting.

According to the current findings, the respondents with unacceptable room lighting had 3.2 times higher chance of having a high RBG level. Similar results have been reported earlier.[3] Bright light has been linked to an increase in postprandial glucose levels in type 2 DM patients.[3]

Other studies showed that bright light can affect glucose metabolism when compared to dim light.[11,12] The effect of night-time light exposure on metabolic function was found to be associated with an increase in sympathovagal balance while sleeping. The amount of brighter night light is linked to an increase in diabetes prevalence.[13]

Exposure to room light affects the body's metabolism. Room light during sleep may disrupt glucose homeostatis, potentially through increased activation of the Sympathetic Nervous System.[14]

## Conclusion

There was a significant effect of temperature and light on blood glucose levels in diabetic patients.

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