

Incidence of type 2 diabetes mellitus among shift workers: a scoping review.

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Abstract

Objectives The purpose of this scoping review was to map the relationship between the increase in the incidence of T2DM among people who work in shifts and what are the possible shift work-related factors associated with this increase.

Methods A scoping review was conducted, following the proposal of the Joanna Briggs Institute. The Population, Concept, and Context strategy was used to formulate the guiding question. The proposed question was: “What is the incidence of type 2 diabetes mellitus among shift workers?”

Results After excluding duplicate articles, analyzing titles and abstracts, and excluding articles that did not answer the guiding question, 8 articles remained and were included in this review. Shift work schedules increase the incidence of T2DM, which was associated with the period the shift work was performed, circadian rhythm dysregulation, the length of exposure, ethnicity, occupation, and socioeconomic status. This increase is also associated with decreased frequency of physical activity, increased smoking rates and excessive calorie consumption with subsequent higher rates of overweight and obesity.

Conclusions Therefore, continuous education and health policy programs for shift workers at the workplace and outside of it, are necessary to avoid or at least postpone the incidence of T2DM among these professionals. Future studies are warranted to fulfill the knowledge gaps involving shift work schedules and the incidence of T2DM.

Keywords: Type 2 Diabetes Mellitus; Shift Work; Circadian Rhythm; Lifestyle; Incidence.

1. Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disease with multifactorial origin. It is generally caused by an interplay between genetic and environmental factors such as unhealthy eating, sedentary lifestyle, adiposity (especially central), and other stressors to glucose metabolism. This disease has its onset when the endocrine pancreas is unable to produce sufficient amounts of insulin or when there is peripheral resistance to its action. The diagnosis of T2DM is made by the presence of high levels of plasma glucose and/or glycated hemoglobin (HbA1c). (1)

Currently, 1 in 10 adults (20 to 79 years old) has a diagnosis of diabetes, which means 537 million people have this diagnosis worldwide. It is estimated that this prevalence will rise to 643 million by 2030 and to 784 million by 2045. High mortality rates are found among people with diabetes which are related to the presence of acute and chronic diabetes-related complications. This condition is also associated with high costs, both direct and indirect. (2)

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Sleeping well is fundamental to the health of the human being. Over the 24 hours of the day, basal concentrations of various hormones vary according to our sleep-wake cycle. Cortisol, for example, has a peak secretion just before awakening that gradually decreases after the first-morning meal. Other hormones such as insulin, adiponectin, melatonin, and growth hormone vary their concentration according to an individual's sleeping, awaking, feeding and working, which we call circadian rhythm. Thus, sleeping well at night is essential to regulate this rhythm, reestablish vital energy, decrease oxidative stress in the body and thus prevent cardiovascular, metabolic and endocrine diseases (3).

The organization of working hours helps to understand the relationship between work and the health of a given population. According to the Brazilian Consolidation of Labor Laws (CLT), the duration of a working day should not exceed 8 hours in order to guarantee rest periods for the workers. Moreover, the night shift work, defined as the work performed between 10:00 pm and 5:00 am of the next day, is considered unhealthy and, those professionals who work for twelve hours in a day should have the next 36 hours of rest (4).

Shift work comprehends working during morning, afternoon, and evening hours, depending on the demands of companies and the labor market. Several professionals have 24-hour journeys during the seven days of the week, such as police officers and health professionals. Thus, the worker can sometimes work in the morning, in the afternoon, or at night, making it difficult to establish a routine. (5)

Shift work is a challenge for the global health system as it interferes with the circadian cycle of individuals, leads to unhealthy lifestyles and increases the risk for several chronic diseases, including T2DM. (5). In our contemporary society, working in alternating shifts is quite common. In the European Union, 20-30% of workers have alternating shifts. (6) Possibly, in the future, an even greater number of people will be working on these schedules and it will be a great issue for health systems.

Some studies warn about a possible increase in the incidence of T2DM in people whose working hours have been in shifts for many years, but the exact mechanisms involved in this process are not well understood. Some argue that working in shifts will lead to a dysregulation of the circadian rhythm by altering concentrations of hormones that are important to the body. Other studies point out that changes in habits and behavior caused by shift work are responsible. All these factors lead at least to an increase in weight, overweight/obesity, insulin resistance, and finally new cases of T2DM (5)

Therefore, the aim of this scoping review is to map the incidence of T2DM among all types of workers who have shift work schedules and analyze the factors that contribute to this outcome.

2. Methods

This study is a scoping review, which follows the methodology proposed by the Joanna Briggs Institute (JBI) that aims to map the information produced on a given topic, revisiting and analyzing the scientific knowledge on this subject, in order to gather scientific information and bringing them to the scientific community. This review was structured through the following steps: (1) elaboration of the guiding question and the scoping review objective; (2) elaboration of search strategy; (3) literature search in databases; (4) selection of articles based on titles and abstracts; (5) selection of scientific articles after full reading; (6) summary of results; and (7) presentation and discussion of results. (7)

To guide this research, the mnemonic Population, Concept, and Context (PCC) was used. (7) In this scoping review, we used the following terms: Population= Workers, Concept= Incidence of type 2 diabetes mellitus; Context= Shift work.

For the search, we defined the use of health descriptors, keywords listed in Table 1, which were associated with the Boolean operators OR, AND, and NOT. (8)

After determining the search terms, the following research question was established: "What is the incidence of type 2 diabetes mellitus among shift workers?"

Following the JBI proposal, two members of the research group (BMD and MGA) independently searched the following databases by electronic means: MEDLINE (Pubmed), EMBASE, Scopus, Web of Science, and Lilacs; in addition to the Scielo platform. Health descriptors defined by the Health Science Descriptors and Medical Subject Headings (DeCS/MeSH) were used, along with their synonyms. When there was disagreement between the two researchers, a third one was consulted (CAN).

The search for this study was performed between April 1st and 30th, 2021. Studies in English and Portuguese, published at any time, such as systematic reviews, randomized clinical trials, cohort studies (prospective and retrospective), observational studies, in addition to laboratory studies and expert review articles, available in full text online, were included. Articles written in languages other than English and Portuguese, those that did not answer the guiding question or those whose full texts were not found in the consulted databases were excluded.

Among the 193 articles found, after the exclusion of duplicate articles with the support of the Mendeley software, 133 articles remained for analysis. Then, after reading the title and abstract, 53 studies were selected for a full reading. Among these, five were included in the study since they met the inclusion criteria. Three studies from *gray literature* were also included as they were found among the bibliographic references of the previously selected articles. Thus, the sample of this research consisted of eight studies. Figure 1 shows the flowchart of this selection process.

Selected articles were called studies (E) and numbered from 1 to 8. The results are presented in the form of tables and discursive reports. To comply with the methodological rigor, the Prism tool adapted for Scoping Review was applied. (7)

3. Results

Among the eight selected studies, all were published in English, conducted in North and South America, Europe, and Asia, and were published in the last 16 years, three of them, were published in the last five years. The analyzed studies were predominantly retrospective and prospective cohort studies (87.50% of the total), with a large number of participants. The average number of participants per study was 128, 855, and a studied systematic review and meta-analysis, enrolled 639,880 people. (9–16)

Table 1 Presentation of descriptors and their synonyms used in this review.

Keyword	Descriptor in Portuguese	Descriptor in English
Population	(Decs: Categorias de trabalhadores) Empregado Empregados Funcionário Funcionários Pessoal Trabalhador Trabalhador Coletivo Trabalhadores Trabalhadores com Vínculo Empregatício Trabalhadores Formais Trabalhadores Informais Trabalhadores sem Vínculo Empregatício Trabalhadores Temporário	(Decs: Occupational Groups) Contractors Employee Employees Group, Occupational Groups, Occupational Occupational Group Permanent Employees Permanent Workers Personnel Temporary Workers Worker Workers Workers without Contract
Concept	Incidência de Diabetes Mellitus, Tipo 2	Incidence of Type 2 Diabetes Mellitus
Context	(Decs: Jornada de Trabalho em turnos) Horário de Trabalho em Turnos Horário de Trabalho por Turnos Trabalho em Turnos Trabalho em Turnos Rotativos Trabalho no Turno da Noite Trabalho Noturno Trabalho por Turnos Trabalho por Turnos Rotativos	(Decs: Shift Work Schedule) Night Shift Work Rotating Shift Work Schedule, Shift Work Schedules, Shift Work Shift Work, Night Shift Work, Rotating Work Schedule, Shift

Table 2 Distribution of the studies according to authorship, year of publication, title and country of origin. Bauru, 2021.

Study	Authors/ year	Title	Country
E1	SILVA-COSTA, A. et al. 2020	Lifetime night work exposure and the risk of type 2 diabetes: results from the longitudinal study of adult health (ELSA-Brasil).	Brazil
E2	GAO, Y. et al. 2020	Association between shift work and risk of type 2 diabetes mellitus: a systematic review and dose-response meta-analysis of observational studies.	China
E3	VETTER, C. et al. 2018	Night shift work, genetic risk, and type 2 diabetes in the UK biobank	United Kingdom
E4	HANSEN A. B. et al. 2016	Night shift work and incidence of diabetes in the Danish Nurse Cohort.	Denmark
E5	VIMALANANDA, V. G. et al. 2015	Night-shift work and incident diabetes among African-American women.	United States
E6	PAN, A. et al. 2011	Rotating night shift work and risk of type 2 diabetes: Two prospective cohort studies in women.	United States
E7	SUWAZONO, Y. et al. 2006	Long-Term Longitudinal Study on the Relationship Between Alternating Shift Work and the Onset of Diabetes Mellitus in Male Japanese Workers	Japan
E8	MORIKAWA, Y. et al. 2005	Shift work and the risk of diabetes mellitus among Japanese male factory workers.	Japan

Table 3 Characterization of the studies according to objectives, design, number of participants, diagnostic criteria for T2DM and shift work. Bauru, 2021.

Study	Objective	Design	Participants (n)	T2DM diagnostic criteria	Period of shifts
E1	To analyze the effects of the period of life exposed to work in night shifts with the risk of developing T2DM among Brazilian public servers, considering possible gender differences.	Prospective Cohort Study	14 014	Based on the American Diabetes Association criteria, the study used laboratory tests and self-reported information to diagnose diabetes: fasting blood glucose (≥ 126 mg/dL), 2-hour postprandial blood glucose (≥ 200 mg/dL) or HbA1 C ($\geq 6.5\%$).	Night shifts were defined as working 5 hours or more during night shifts [10:00 pm - 5:00 am] at least 4 times a month.
E2	In addition to studying the relationship between shift work and increased risk of having T2DM, this meta-analysis aimed to focus on	Systematic Review and Meta-analysis	639 880	At least, one of the following criteria: Fasting blood glucose ≥ 7.0 mmol/l (≥ 126 mg/dL), 2-hour postprandial blood glucose ≥ 11.1 mmol/l (≥ 200 mg/dL), HbA1 C $\geq 6.5\%$, random	Shift work is defined as working outside conventional daytime hours from 9:00 am to 5:00 pm, which includes night, morning, afternoon and the rotation of these non-specific shifts. Each study analyzed in this systematic review

	<p>classifying and analyzing patients with diabetes. Furthermore, it is expected from a considerable number of studies to establish a dose-response analysis between exposure to shift work and the development of T2DM.</p>			<p>blood glucose ≥ 11.1 mmol/l (≥ 200 mg/dL) or 75 g oral glucose tolerance test with fasting blood glucose ≥ 7.0 mmol/l (≥ 126 mg/dL) and/or 2-hour plasma glucose ≥ 11.1 mmol/l (≥ 200 mg/dL).</p>	<p>presented its specificities in relation to the definition of shift work.</p>
E3	<p>To examine the role of past and current night shift work and vulnerability for T2DM.</p>	<p>Retrospective and cross-sectional cohort study</p>	<p>272 214</p>	<p>An Eastwood algorithm was used to diagnose T2DM. This algorithm is based on self-reported information, medication use and the patient's medical history that is evaluated by a trained health professional. This method has been validated at the UK Biobank using primary and secondary patient medical records with an accuracy of 96%.</p>	<p>Night shift workers were considered to be those who worked between 00:00 and 6:00 hours. The exposure time in years to this type of work was also evaluated.</p>
E4	<p>Investigate the association between shift work and the incidence of DM2 over 13 years among nurses participating in the "Danish Nurses Cohort" (Danish Nurses Cohort Study).</p>	<p>Prospective Cohort Study</p>	<p>19 873</p>	<p>The "Danish National Diabetes Register (NDR)" was established to describe and monitor the prevalence and incidence of different types of diabetes in Denmark. The diagnosis of DM2 in the participants of this study was based on their registration in the NDR. Therefore, to be registered in the NDR, a person should meet at least one of the following criteria: (1) Have been hospitalized with DM2. (2) having</p>	<p>The characterization of the participants' work shift was established through a questionnaire assessing whether the nurse worked during the day, in the afternoon, at night or if she rotated shifts. This information was added to the information obtained through the "Danish Central Population Register (CPR)" to obtain the necessary information from each participant.</p>

				used the services of a podiatrist as a diabetic patient. (3) have at least 5 blood glucose measurements within one year. (4) have at least 2 blood glucose measurements during 5 consecutive years.	
E5	Evaluate the relationship between the incidence of T2DM and working shifts among African-American women.	Prospective Cohort Study	28 041	Participants were diagnosed during the study or in routine medical consultations. The diagnosis of T2DM was also made in women who had HbA1 C $\geq 6.5\%$, without a previous history of diabetes or any other condition that justifies their hyperglycemia.	Night shifts were defined as the work shift between 00:00 and 08:00 am. The length of working in this schedule was also considered. These responses were categorized as (never, 1-2 years, 3-9 years and more than 10 years).
E6 (NHS I)	Evaluate the results of two prospective cohort studies "Nurses Health Study I and II" in order to study the association between night and rotating shift work with circadian rhythm dysfunctions and their metabolic consequences regarding obesity, metabolic syndrome and blood glucose dysregulation.	Prospective Cohort Study	69 269	At least one of the following criteria: (1) have one or more of the classic symptoms of T2DM (polyuria, polydipsia, polyphagia, or weight loss) plus fasting blood glucose of 7.8 mmol/l (140 mg/dL) or random blood glucose of 11.1 mmol/l (200 mg/dL). At least two fasting blood glucose measurements > 7.8 mmol/l (140 mg/dL) or two random blood glucose measurements > 11.1 mmol/l (200 mg/dL) or blood glucose > 11.1 mmol/l (200 mg/dL) (3) Treatment with insulin or oral antidiabetic drugs was considered.	Working at least 3 nights a month, along with working days and afternoons in the same month. Questionnaires collected information on the total number of months each nurse worked rotating night shifts in the past.
E6 (NHS II)		Prospective Cohort Study	107 915		

E7	To investigate the effects of alternating shift work on the incidence of T2DM in Japanese workers, comparing those who work in fixed daily shifts with those who work in rotating shifts	Prospective Cohort Study	5629	a) Results of an annual laboratory examination and b) individual medical history. Laboratory test results confirmed the diagnosis of T2DM when HbA1c was $\geq 6\%$, along with medical evaluation. The diagnosis was also considered when the participant was diagnosed by a clinical evaluation performed by a physician.	Alternating shift work consisted of four groups with a three-shift system having a rotation in a programmed direction (5 day shifts and two days off, 5 afternoon shifts and one day off, and 5 night shifts with 2 days off). The day, afternoon and night shifts started at 7:00 am, 3:00 pm and 11:00 pm, respectively.
E8	Investigate the importance of shift work as a risk factor for the occurrence of new cases of T2DM.	Prospective Cohort Study	2860	The diagnosis of T2DM was based on the presence of HbA1c $\geq 6.1\%$ or having had a previous diagnosis made by a physician. Blood glucose was not used as a diagnostic criterion.	Workers were classified into two types: white collar and blue collar. The white collar employees were executives and always worked fixed day shifts. The blue-collar workers corresponded to the manual workers. These workers performed the following three types of shifts: fixed day shifts, two rotating shifts and three rotating shifts. The three rotating shifts occupied the workers in a counterclockwise direction with two-thirds of their shifts in discontinuous shifts (5 day shifts, 5 night shifts and 5 afternoon shifts) and one-third of the shifts in continuous shift (3 or 4 day shifts, 3 or 4 night shifts and 3 or 4 afternoon shifts, with one day off after successive shifts). Shift change times were 08:00 am to 4:30 pm, 00:15 am to 06:30 am and 1:00 pm to 9:30 pm. Workers on two rotating shifts had a discontinuous shift system between morning and afternoon.

Table 4 Characterization of the studies according to gender, occupation, shift work, exposure time to shift work, incidence of T2DM and its risk ratio.

Study	Gender	Occupation	Shift work	Exposure time	Incidence of DM2 (person/year)*	Risk Ratio
E1	Women	Public workers	Conventional shifts	Never	15,0/1000	1
			Night shifts	Ten or more years	22,6/1000	1,46 (1,03 - 2,08)
			Night shifts	Less than ten years	16,4/1000	1,17 (0,75 - 1,81)
	Men	Public workers	Conventional shifts	Never	18,2/1000	1
			Night shifts	Ten or more years	14,4/1000	0,56 (0,4 - 1,03)
			Night shifts	Less than ten years	22,3/1000	1,16 (0,82 - 1,65)
E2	Both	Several types of occupations	Night shifts	Not informed	Not informed	1,15 (1,08 - 1,24)
			Alternating shifts	Not informed	Not informed	1,08 (1,04 - 1,12)
			Morning shifts	Not informed	Not informed	1,29 (1,04 - 1,59)
			Not categorized	Not informed	Not informed	1,02 (0,91 - 1,14)
E3	Both	Not specified	Night shifts	Never	Not informed	1
			Night shifts	Up to five years	Not informed	1,37
			Night shifts	Between five and ten years	Not informed	1,57
			Night shifts	More than ten years	Not informed	1,47
E4	Women	Nurses	Day shifts	Not informed	2,64/1000	1
			Morning shifts	Not informed	3,33/1000	1,24 (1,01 - 1,53)
			Night shifts	Not informed	4,92/1000	1,84 (1,46 - 2,31)
			Rotating shifts	Not informed	2,61/1000	1,04 (0,87 - 1,23)
E5	Women	Not specified	Never worked shifts	Never	8,3/1000	1
			Night shifts	One to two years	10,2/1000	1,17 (1,04 - 1,31)
			Night shifts	Three to nine years	11,2/1000	1,23 (1,06 - 1,41)
			Night shifts	Ten years or more	15,5/1000	1,42 (1,19 - 1,70)
E6 (NHS I)	Women	Nurses	Never worked shifts	Never	4,5/1000	1
			Alternating shifts	One to two years	4,5/1000	0,99 (0,93 - 1,06)
			Alternating shifts	Three to nine years	5,3/1000	1,17 (1,10 - 1,25)
			Alternating shifts	10 to 19 years	6,3/1000	1,42 (1,29 - 1,55)
			Alternating shifts	20 years or more	7,4/1000	1,64 (1,46 - 1,83)
E6 (NHS II)	Women	Nurses	Never worked shifts	Never	1,7/1000	1
			Alternating shifts	One to two years	2,0/1000	1,13 (1,04 - 1,23)

			Alternating shifts	Three to nine years	2,3/1000	1,34 (1,23 - 1,45)
			Alternating shifts	10 to 19 years	3,5/1000	1,76 (1,57 - 1,96)
			Alternating shifts	20 years or more	7,1/1000	2,5 (2,00 - 3,14)
E7	Men	Steel factory workers	Day shifts	Not informed	5,7/1000	1
			Alternating shifts	Not informed	7,41/1000	1,35 (1,05 - 1,75)
E8	Men	Executive workers (White color)	Day shifts	Not informed	3,34/1000	1
			Men	Manual workers (Blue color)	Day shifts	Not informed
		Two rotating shifts	Not informed		6,84/1000	1,93 (0,95 - 3,91)
		Three rotating shifts	Not informed		5,32/1000	1,51 (0,83 - 2,74)

*Incidence was calculated using the following formula: cases/participants*years of follow-up; **Rated risk ratio calculated by the ratio of incidence of T2DM on shift work compared to workers that were never exposed to shift work.

A high heterogeneity among the studies of shift work schedules and its impact on the prevalence of the disease according to gender, duration of exposition to shift work, socioeconomic status, and occupation was found, regarding the definition of T2DM. (9,11,16) In general, working in shifts increased the risk of developing T2DM.

Characterization of the studies according to authorship, year of publication, title and country of origin are shown in Table 2. (9–16)

The diagnostic criteria for T2DM diagnosis was different among studies, as well as the interpretation of working hours in alternating shifts. Table 3 presents the studies according to their objectives, design, number of participants, diagnostic criteria for T2DM and characteristics of shift work. (9–16)

A great diversity of criteria for diagnosing T2DM was found among the evaluated studies. Some considered fasting blood glucose (≥ 126 mg/dL), or 2-hour postprandial blood glucose (≥ 200 mg/dL) or even HbA1c ($\geq 6.5\%$) as diagnostic criteria. (1,10,13,14) In some studies, the levels of HbA1c considered for diagnosis were lower than 6,5%. (15,16) Some centers assessed public health care system databases in order to diagnose T2DM. (10,11) Sometimes, the diagnosis was performed during routine checkups. (11–14) These data are shown in table 3.

Each study had also its definition of work shifts, regarding morning, afternoon, night, and day work schedules, in addition to different frequency of shifts.

The incidence and risk ratio for T2DM, according to gender, occupation, shift schedule, and length of exposure are shown in Table 4.

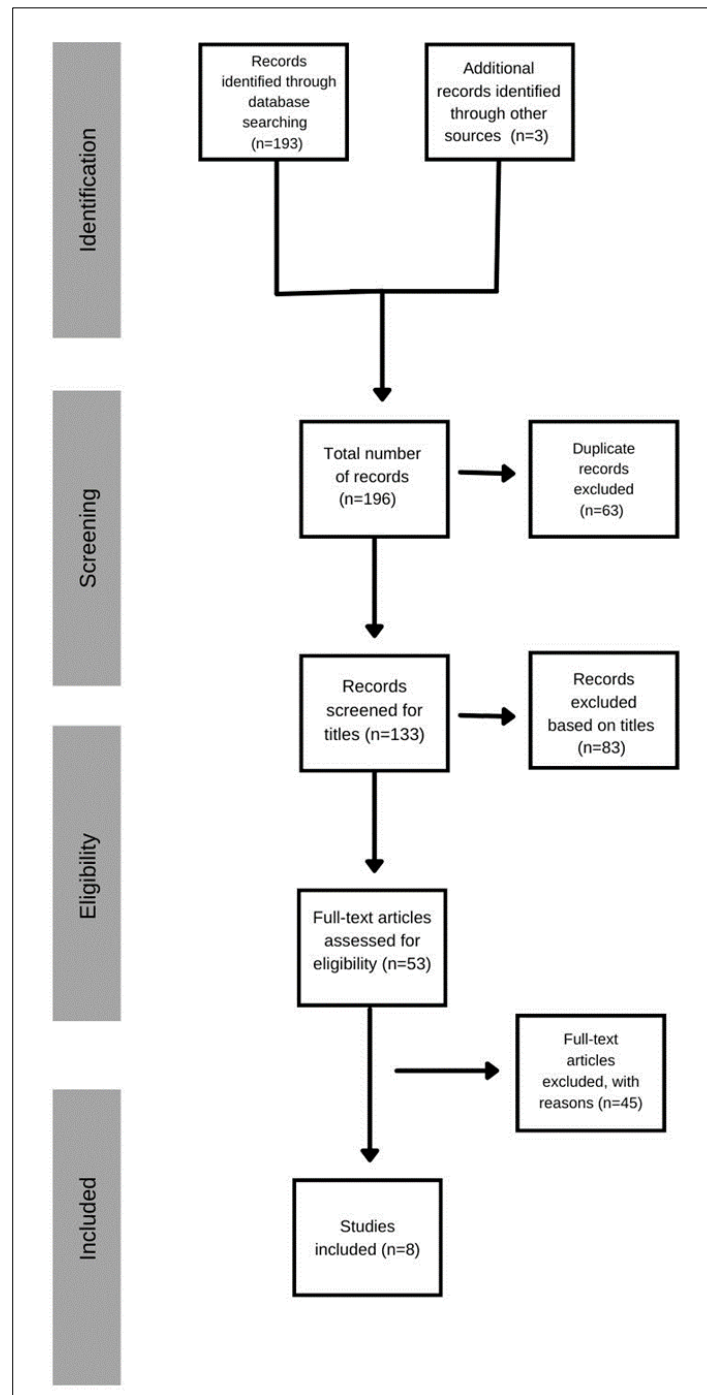


Figure 1 Flowchart regarding the selection of included articles

4. Discussion

Despite the heterogeneity of the studies enrolled in this review, a uniformity between exposure to shift work and increasing incidence of T2DM was found. (9–16)

The definition of shift work was also diverse. In general, shift work was defined when there was a working schedule outside the conventional daytime hours, which covers the period from 9:00 pm to 6:00 am the next day. (8) Thus, shift work can be considered to involve associations between morning, afternoon, night, or alternating shifts.

Each study defined shift work in different ways. The afternoon shift was defined as follows: from 3:00 pm to 11:00 pm (12,15) and from 1:00 pm to 9:00 pm. (16) As a result, it can be seen that the afternoon shift goes beyond 5:00 pm, covering part of the night period, which makes it difficult to evaluate its impact on the circadian rhythm.

The day shift had also different definitions. E3 has adopted a conventional shift that is performed between 9:00 am and 5:00 pm; however, in E2, which is a systematic review, each study evaluated had its definition of day shift. At E4 and E7, the morning shift was considered from 7:00 am to 3:00 pm, and at E8, from 8:00 am to 4:30 pm. (9–16) E4 has found a 29% higher risk of presenting T2DM in participants whose shifts were during the morning. (12)

Regarding night shift work, E1 considered night shifts those that lasted five or more hours, with a minimum frequency of four shifts per month, between 10:00 pm and 5:00 am (1) On the other hand, E3 considered the night shift between 00:00 and 6:00 hours;(10) in E4 and E7, this shift ran from 11:00 pm to 7:00 am. (12,15) In E5, night shift was considered from 00:00 to 08:00 hours, in E8, from 00:15 to 6:15 hours and E6 did not present a precise definition.(12,13,15) E4 found an increased risk of having T2DM ranging from 46% to 131% comparing nurses working night shifts to those working day shifts. (1)

Rotating shift work was another diverging factor regarding its definition. E4 did not present a clear definition of what rotating shifts were, (12) E6 considered alternating or rotating shifts when the participant worked day and morning shifts with at least 3-night shifts in a month.(14) E7 had participants whose shifts were part of a rotating system, alternating between morning, afternoon, and night shifts and, in E8, there were two types of alternating shifts: one with a three-period cycle system (the worker had a five-day cycle of night shifts, then five mornings and five-day shifts) and another system, with periods of 3- or 4-night, day or morning shifts.(15,16) In this context, a higher incidence of T2DM was found among participants in alternating shifts compared to those with fixed shifts in some studies,(14–16) but was not found in one study following this schedule.(13) E7 and E8 showed an increase of 35% and 70% among workers on alternating shifts, respectively.(15,16)

The length of exposure to shift work was also an important factor for the onset of T2DM in many studies. E1 showed an increased risk of 17% in women with less than 10 years of shift work and 46% in those with more than 10 years. (9) E3 showed 37%, 57%, and 47% increased risk of having T2DM in night workers with up to 5 years of exposure, between 5 and 10 years and more than 10 years, respectively. (11) African-American women presented 17%, 23%, and 42% increased risk with 1 to 2 years, 3 to 9 years, and 10 years or more of exposure, respectively at E5. (13)

E6 comprised two studies: Nurses Health Study I (NHS I) and Nurses Health Study II (NHS II) which evaluated volunteer nurses, who were grouped according to the length of time they worked in rotating night shifts (never, 1 to 2 years, 3 to 9 years, 10 to 19 years or more than 20 years). An increase in the incidence of T2DM was found in parallel with the length of exposure to rotating night shifts. The NHS I showed an increase ranging from 17% to 64% and the NHS II, 13% to 150% in groups with 1 to 2 years, compared to those who worked more than 20 years, respectively. (14)

In addition, unconventional working hours were related to a worse lifestyle among participants, with higher rates of smoking, unhealthy diets, and lower rates of physical activity. Therefore, these workers smoked more, (11–15) had higher caloric consumption, (12,13) practiced less frequently physical activities (12,15), and had higher BMI. (11–14)

A higher incidence of T2DM among men with lower work qualifications was found, especially among shift workers. This result shows that socioeconomic factors are also correlated with the onset of T2DM. (16) However, an increasing incidence of T2DM was not linked to a specific professional category. (9,12–16)

It is unclear if gender is a relevant variable. E1 found an increased risk of T2DM only in women. (9) In this study, an increase in the risk of 17% and 46% was found for women with less and more than 10 years of exposure to shift work, respectively. However, among men, the incidence of T2DM in those who never worked in shifts was 1.82/100 person-years; those with less and more than 10 years of shift work had an incidence of 1.44/100 and 2.23/100 person-years, respectively, which was considered not to be statistically significant. (9) The other studies were carried out exclusively with men or women, which does not allow this comparison to be done. (12–16)

In this review, it was found an increase in the incidence of T2DM among shift workers. This finding should motivate the search for pragmatic interventions regarding the reduction and/or prevention of T2DM among these workers.

These workers should receive support and education as early as possible regarding the prevention of T2DM ever since they start their professions. Several adjustments regarding diet, exercise, quitting smoking and a healthier lifestyle should be implemented at the workplace and outside of it.

Limitations

This review has some limitations that must be addressed. Although we have been methodical in the search and identification of published literature, important sources of information may have been omitted because we did not search all available databases and we also did not include articles written in languages other than English and Portuguese, which could have added new data that could modify the conclusions of this study. Furthermore, there was heterogeneity in the criteria for diagnosing T2DM, in the definitions of shift work and of working periods, which led to a diversity of data obtained in different parts of the world and different populations. Thus, future studies should be carried out to better understand the impact of shift work schedules on the incidence of T2DM in different ethnicities, genders, and social classes. In a scoping review, no evidence quality rating is provided, so implications for clinical practice cannot be rated.

5. Conclusion

Shift work schedules increased the incidence of T2DM, which was associated with the period the shift work was performed, the length of exposure, ethnicity, occupation, and socioeconomic status. This increase is also associated with decreased frequency of physical activity, increased smoking rates, and excessive calorie consumption with subsequent higher rates of overweight and obesity. Therefore, we should aim at providing continuous education and health policy programs for shift workers in the workplace and outside of it, to avoid or at least postpone the occurrence of T2DM among these professionals. Future studies are warranted to fulfill the knowledge gaps involving shift work schedules and the incidence of T2DM.

Compliance with ethical standards

Statement of conflicts of interests

The authors have no conflicts of interest to declare.

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Authors contributions

All authors contributed equally to the manuscript.

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