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Application of the FINDRISK Test for the Detection and Monitoring of Type 2 Diabetes Mellitus Risk in Primary Care

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ABSTRACT

Introduction: Type 2 diabetes mellitus affects millions of people worldwide and often remains undiagnosed until complications arise. In primary care centers, where early warning signs are first detected, having practical tools to help identify individuals at risk can make a significant difference in the lives of many patients. The FINDRISK test represents a concrete opportunity to anticipate the disease.

Objective: To determine the risk of developing T2DM according to the FINDRISK test in a USF of the Paraguayan public health system and determine the biochemical parameters of patients with moderate to very high risk according to the FINDRISK test. In addition, the sociodemographic characteristics of the population were detailed, and the parameters evaluated in the applied test were described.

Methodology: An observational, descriptive, and cross-sectional study was conducted in two phases. In the first phase, the FINDRISK test was applied to 460 individuals over 18 years of age. In the second phase, clinical and laboratory assessments were performed on patients with moderate to very high risk (142 individuals), including fasting glucose, glycated hemoglobin, and lipid profile, as well as the application of metabolic syndrome criteria according to *ATP-III*.

Results: 30.9% of patients assessed with the FINDRISK test presented a moderate to very high risk of developing type 2 diabetes. Among these, elevated rates of overweight or obesity (70.4%), physical inactivity (68.3%), family history of type 2 diabetes (45.1%), and low consumption of fruits and vegetables (59.2%) were observed. Laboratory analyses in this group demonstrated metabolic alterations: 69.7% had prediabetic values, and 10.6% had HbA1c values greater than 6.5%. Metabolic syndrome was present in more than a quarter of cases according to *ATP-III* criteria, with a statistically significant association with patients exhibiting any degree of risk as per the test.

Conclusion: The implementation of the FINDRISK test enabled the timely identification of a significant group of individuals at risk for type 2 diabetes. Its use in primary care, accompanied by clinical and laboratory follow-up, represents a viable, accessible, and replicable strategy to improve community health.

Keywords: Type 2 diabetes mellitus, prevention, primary care, FINDRISK.

Introduction.

Type 2 diabetes mellitus (T2DM) is one of the leading causes of morbidity and mortality worldwide. It is characterized by persistent hyperglycemia resulting from a combination of insulin resistance and a relative deficiency in insulin secretion, and currently represents one of the greatest global health challenges due to its social, clinical, and economic impact[1]. According to the latest report from the International Diabetes Federation (IDF), more than 537 million people are living with diabetes worldwide, and this figure could reach 783 million by 2045 if effective prevention strategies are not implemented[2]. In Latin America, the situation is particularly concerning, with an average prevalence of 9.4% among adults and a high proportion of undiagnosed cases[3].

In Paraguay, the Second National Survey of Risk Factors conducted in 2022 reported that 10.6% of adults have a diagnosis of diabetes[4]. This scenario highlights the urgent need to implement early detection strategies to identify individuals at risk of developing the disease, particularly at the primary care level.

Clinical practice guidelines from organizations such as the World Health Organization (WHO) and the American Diabetes Association (ADA) recommend the use of validated screening tools to identify individuals at high risk of developing T2DM, as a preliminary step before diagnostic confirmation through biochemical tests[5-7]. Among these tools, the FINDRISK test (Finnish Diabetes Risk Score), developed by Lindström and Tuomilehto in 2003, has been established as one of the most effective, simple, and low-cost instruments for estimating the 10-year risk of developing T2DM[8].

The FINDRISK test has been validated in multiple countries and sociocultural contexts, consistently demonstrating good sensitivity and specificity[9-13]. In Latin America, studies conducted in Brazil, Ecuador, Colombia, and Mexico have confirmed its usefulness in primary care, in both rural and urban populations, including settings with limited resources. Moreover, recent systematic reviews have supported its applicability as a population screening tool in various regions worldwide[12]. In Paraguay, local research has shown that the FINDRISK test is feasible for implementation in Family Health Units (USF), with good patient acceptability and clinical utility for guiding preventive interventions[13].

This article presents research developed in two consecutive phases in a USF within the Paraguayan public health system. The FINDRISK test was administered to adults without a prior diagnosis of T2DM, and a biochemical evaluation was performed on those classified as having moderate to very high risk.

The general objective was to determine the risk of developing T2DM according to the FINDRISK test in a USF of the Paraguayan public health system and determine the biochemical parameters of patients with moderate to very high risk according to the FINDRISK test. In addition, the sociodemographic characteristics of the population were detailed, and the parameters evaluated in the applied test were described.

Materials and Methods.

A prospective, observational, descriptive, and cross-sectional study with an analytical component was conducted in two consecutive phases at a USF within the public health system in Paraguay. This USF serves an urban and peri-urban population and is staffed by a multidisciplinary team that provides medical consultations, health promotion, prevention, and community follow-up activities.

The USF is located in the Chaipe neighborhood of the city of Encarnación, Itapúa department, approximately seven kilometers from the Regional Hospital of Encarnación, the referral center for the department. The study period was divided into two stages: the first stage, corresponding to the application of the data collection instrument, took place from March to July 2022; the second stage, involving the determination of biochemical analyses, was conducted from August 2022 to February 2023.

The study population was selected through non-probabilistic convenience sampling. Inclusion criteria were patients over 18 years of age who attended general consultations at the aforementioned USF during the period of test application (stage 1), without a prior diagnosis of the disease under study, who voluntarily agreed to participate by signing informed consent, and who, based on the results of the first stage, subsequently agreed to undergo free biochemical analyses (stage 2). Pregnant women and patients not belonging to the USF's catchment area were excluded.

Epi Info™ statistical software version 7.2.0.1 was used. To achieve the study objective, a sample size of 342 patients was required, based on an expected proportion of 50%[14]. The estimate was calculated with a 95% confidence level and a 0.5% precision in a universe of 3,150 patients meeting the inclusion criteria. Ultimately, in the first phase of the study, the test was applied to a total of 460 individuals.

In the first phase, the primary care physician administered the test during the consultation. The FINDRISK test assigns a score to each variable: age (0 points: <45 years; 2 points: 45–54 years; 3 points: 55–64 years; 4 points: >64 years), body mass index (BMI, 0 points: <25 kg/m²; 1 point: 25–30 kg/m²; 3 points: >30 kg/m²), waist circumference (Men: 0 points: <94 cm; 3 points: 94–102 cm; 4 points: >102 cm. Women: 0 points: <80 cm; 3 points: 80–88 cm; 4 points: >88 cm), physical activity at least 30 minutes per day at work and/or leisure (0 points: yes; 2 points: no), daily consumption of fruits or vegetables (0 points: every day; 1 point: not every day), antihypertensive medication (0 points: no; 2 points: yes), history of hyperglycemia (0 points: no; 5 points: yes), and family history of diabetes mellitus (0 points: no; 3 points: grandparents, uncles/aunts, or first cousins; 5 points: parents, siblings, or children)[8].

The sum of the scores yields a result that translates into risk (low: <7 points, slightly elevated: 7–11 points, moderate: 12–14 points, high: 15–20 points, very high: >20 points) of developing T2DM in the next 10 years[8]. The FINDRISK test has been validated in different populations and clinical settings, demonstrating good internal consistency, with reported Cronbach's alpha values between 0.82 and 0.89[15–17]. In primary care studies, the instrument has shown sensitivity between 77% and 87% and variable specificity, with values between 50% and 70%, making it a useful tool for initial risk screening for T2DM[16–18]. Once results were obtained, each patient was contacted to provide their reports.

In the second phase, participants who scored moderate, high, or very high risk underwent blood sampling for biochemical analyses: HbA1c (%), fasting plasma glucose, total cholesterol, HDL cholesterol, and triglycerides (all in mg/dL). Participants were instructed to observe a minimum fasting period of 8 hours[19] prior to blood collection. Blood samples were collected at each participant's home. The USF community health worker identified home addresses using a reference map provided to the health personnel responsible for sample collection.

All recommended procedures for sample collection and transport were followed, as per the private laboratory in the city responsible for processing the samples. Additionally, metabolic syndrome criteria were applied according to the *National Cholesterol Education Program Adult Treatment Panel III (ATP-III)*[20], which requires at least three of the following components: central obesity, hyperglycemia, hypertriglyceridemia, low HDL cholesterol, and elevated blood pressure. A total of 142 individuals participated in this phase of the study.

Data were recorded on structured forms, then coded and stored digitally. Data analysis was performed using Epi Info™ version 7.2.0.1. Descriptive statistics were applied, using means and standard deviation for quantitative variables, and absolute and relative frequencies for qualitative variables. The level of statistical significance was set at $p \leq 0.05$.

Participant anonymity was ensured by assigning alphanumeric codes, and bioethical principles as well as individual and social principles established by UNESCO were respected.

The research protocol was approved by the Research and Environment Directorate of the National University of Itapúa, according to Resolution N° 199/2022.

Results.

The FINDRISK test was applied as a screening tool to identify risk factors for T2DM in a Paraguayan population, following a structured methodological approach in two clearly differentiated phases, which allowed for the assessment of both potential risk and metabolic alterations in the participants.

General characteristics of the study population.

The study included 460 adults without a prior diagnosis of T2DM who attended the USF in the Chaipe neighborhood of Encarnación, Paraguay. The average age of participants was 45.3 years (SD ± 13.7), with a predominance of females (62.8%).

Risk stratification using the FINDRISK test.

The results of the FINDRISK test showed a heterogeneous distribution of the risk of developing diabetes within the study population (Table 1).

Table 1. Risk of T2DM according to the FINDRISK test. Family Health Unit of the Chaipe neighborhood (n=460)

Risk level	Total	%
Low	130	28,26
Slightly elevated	188	40,87
Moderate	91	19,78
High	50	10,87
Very high	1	0,22

Clinical profile of participants according to the FINDRISK test.

Table 2 describes the clinical profile of the participants. A high prevalence of modifiable risk factors was observed: 73.7% (n=339) had increased waist circumference, 63.9% (n=294) were overweight or obese according to BMI, 47.8% (n=220) reported not engaging in regular physical activity, and 25.4% (n=117) did not consume fruits and vegetables daily. These findings underscore the importance of nutrition and physical activity as central pillars of any preventive strategy. In addition, non-modifiable risk factors or pre-existing conditions were identified: 18.3% (n=84) reported a personal history of hypertension, 8.9% (n=41) had a history of hyperglycemia, and 44.3% (n=204) had a family history of T2DM. The coexistence of multiple risk factors in this subgroup confirms the effectiveness of the FINDRISK test in identifying high-risk profiles using accessible clinical parameters prior to the need for initial laboratory testing.

Table 2. Clinical profile according to T2DM risk based on the FINDRISK test. Family Health Unit of the Chaipe neighborhood (n=460)

Variables	Risk level				
	Low (n=130)	Slightly elevated (n=188)	Moderate (n=91)	High (n=50)	Very high (n=1)
Age group					
< 45 años	122 (93,85%)	135 (71,81%)	47 (51,65%)	15 (30%)	
45-54 años	7 (5,38%)	33 (17,55%)	15 (16,48%)	9 (18%)	
55-64 años		9 (4,79%)	17 (18,68%)	9 (18%)	1 (100%)
> 64 años	1 (0,77%)	11 (5,85%)	12 (13,19%)	17 (34%)	
BMI					
< 25 kg/m2	98 (75,38%)	62 (32,98%)	6 (6,59%)		
25-30 kg/m2	32 (24,62%)	72 (38,30%)	34 (37,36%)	18 (36%)	
> 30 kg/m2		54 (28,72%)	51 (56,04%)	32 (64%)	1 (100%)

Variables	Risk level				
	Low (n=130)	Slightly elevated (n=188)	Moderate (n=91)	High (n=50)	Very high (n=1)
Abdominal circumference (Men)					
< 94 cm	29 (22,31%)	8 (4,26%)	3 (3,30%)	1 (2%)	
94-102 cm		10 (5,32%)	6 (5,59%)	4 (8%)	
> 102 cm		11 (5,85%)	11 (12,09%)	8 (16%)	1 (100%)
Abdominal circumference (Women)					
< 80 cm	52 (40%)	21 (11,17%)			
80-88 cm	30 (23,08%)	37 (19,68%)	5 (5,49%)	1 (2%)	
> 88 cm	19 (14,62%)	101 (53,72%)	66 (72,53%)	36 (72%)	
Physical activity					
Yes	84 (64.62%)	96 (51,06%)	43 (47,25%)	17 (34%)	
No	46 (35,38%)	92 (48,94%)	48 (52,75%)	33 (66%)	1 (100%)
Fruit and vegetable intake					
Every day	110 (84,62%)	138 (73,40%)	69 (75,82%)	26 (52%)	
Not every day	20 (15,38%)	50 (26,60%)	22 (24,18%)	24 (48%)	1 (100%)
Antihypertensive medication					
Yes	1 (0,77%)	29 (15,43%)	28 (30,77%)	25 (50%)	1 (100%)
No	129 (99,23%)	159 (84,57%)	63 (69,23%)	25 (50%)	
History of hyperglycemia					
Yes	3 (2,31%)	16 (8,51%)	7 (7,69%)	14 (28%)	1 (100%)
No	127 (97,69%)	172 (91,49%)	84 (92,31%)	36 (72%)	
Family history of DM					
No	110 (84,62%)	117 (62,23%)	23 (25,27%)	6 (12%)	
Yes: grandparents, uncles, cousins	16 (12,31%)	36 (19,15%)	25 (27,47%)	5 (10%)	
Yes: parents, siblings, children	4 (3,08%)	35 (18,62%)	43 (47,25%)	39 (78%)	1 (100%)

Biochemical parameters in participants with moderate to very high risk.

Risk stratification using the FINDRISK test revealed that approximately one third of the study population (30.9%, n=142) presented a moderate to very high risk of developing T2DM, thus identifying the group for the second phase involving laboratory analyses (Table 3).

Among these participants, 11.97% (n=17) had fasting blood glucose ≥100 mg/dL, indicating impaired fasting glucose; of these, 4.9% (n=7) had values ≥126 mg/dL. Regarding HbA1c, 80.3% (n=114) had values ≥5.4%, and 10.6% (n=15) had HbA1c ≥6.5%. In terms of lipid profile, 14.1% (n=20) had total cholesterol ≥200 mg/dL, 11.97% (n=17) of men had HDL cholesterol ≤40 mg/dL, and 50.7% (n=72) of women had HDL cholesterol ≤50 mg/dL. Additionally, 19.7% (n=28) had triglyceride levels ≥150 mg/dL.

Table 3. Laboratory parameters in patients at risk of T2DM according to the FINDRISK test. Family Health Unit of the Chaipe neighborhood (n=142)

Variable	Risk level		
	Moderate (n=91)	High (n=50)	Very high (n=1)
Fasting glucose			
< 100 mg/dl	86 (94,51%)	39 (78%)	
100 y 125 mg/dl	5 (5,49%)	5 (10%)	
≥ 126 mg/dl		6 (12%)	1 (100%)
HbA1c (%)			
< 5.4 %	20 (21,98%)	8 (16%)	
5,4 y 6,4 %	65 (71,43%)	32 (64%)	
≥ 6,4 %	6 (6,59%)	10 (20%)	1 (100%)
Total cholesterol			
< 200 mg/dl	79 (86,81%)	42 (84%)	1 (100%)
≥ 200 mg/dl	12 (13,19%)	8 (16%)	
HDL cholesterol (Men)			
< 40 mg/dl	7 (41,18%)	10 (52,63%)	
≥ 40 mg/dl	10 (58,82%)	9 (47,37%)	1 (100%)
HDL cholesterol HDL (Women)			
< 50 mg/dl	48 (64,86%)	24 (77,42%)	
≥ 50 mg/dl	26 (35,14%)	7 (22,58%)	
Triglycerides			
< 150 mg/dl	79 (86,81%)	35 (70%)	
≥ 150 mg/dl	12 (13,19%)	15 (30%)	1 (100%)

Diagnosis of metabolic syndrome according to *ATP-III*. A total of 24.64% (n=35) of participants met the criteria for metabolic syndrome according to the ATP-III definition. A statistically significant association was found with a *p*-value of 0.0038. The most frequent combination was increased waist circumference, elevated blood pressure, and elevated triglycerides (Table 4).

Table 4. Metabolic syndrome according to T2DM risk based on the FINDRISK test. Family Health Unit of the Chaipe neighborhood (n=142)

ATP-III Criteria (≥ 3 components)	Risk level		
	Moderate (n=91)	High (n=50)	Very high (n=1)
Yes	15 (42,86%)	19 (54,29%)	1 (2,86%)
No	76 (71,03%)	31 (28,97%)	

Discussion

Type 2 diabetes mellitus is a chronic disease with high prevalence and a growing impact on global public health, particularly in middle-income countries such as Paraguay, where epidemiological transition and lifestyle changes have increased the burden of metabolic diseases[21,22]. In this context, early detection of at-risk individuals is a key strategy for T2DM prevention and control. This study, conducted at the USF in the Chaipe neighborhood (Encarnación, Paraguay), provides relevant local evidence on the usefulness of the FINDRISK test as a screening tool in primary care, supplemented by clinical and laboratory evaluation.

The sample consisted of 460 adults without a previous diagnosis of T2DM, with a mean age of 45.3 years (SD ± 13.7) and a predominance of female participants (62.8%). This composition reflects the typical profile of primary care users in Paraguay and other Latin American countries, where women tend to participate more actively in preventive health activities[23,24].

Regarding risk stratification, 28.26% of participants presented low risk, 40.87% slightly elevated risk, 19.78% moderate risk, 10.87% high risk, and 0.22% very high risk. Thus, 30.9% (n = 142) of participants were classified within the moderate to very high-risk group, who were included in the study's second phase. This proportion is comparable to reports from Colombia (28%)[23] and Nicaragua (34.6%)[25], suggesting that Paraguay's metabolic risk burden is similar to that of other Latin American countries. The consistency of these findings supports the utility of FINDRISK as an initial screening tool and suggests its systematic implementation could be replicated across different regional contexts.

A high prevalence of increased abdominal circumference (73.69%) and overweight/obesity (63.91%) was highlighted—factors identified as key determinants in the progression to T2DM[26,27]. Sedentarism (47.82%) and low fruit and vegetable intake (25.43%) further underscore the need for community-based interventions promoting healthy lifestyles.

The 44.34% of participants with a family history of T2DM highlights the relevance of genetic predisposition, while the coexistence of hypertension (18.26%) and prior hyperglycemia (8.91%) suggests a high-risk metabolic profile, consistent with findings of another study[24]. These data justify the implementation of primary and secondary prevention strategies from the first level of care.

When comparing these findings with international literature, it appears that the prevalence of central obesity and sedentary behavior in the Paraguayan sample is even higher than in some European and North American studies. This may be related to sociocultural, economic, and environmental factors specific to the region[21,28]. This reinforces the need to adapt preventive interventions to local realities, considering specific barriers to adopting healthy lifestyles.

Fasting blood glucose ≥100 mg/dL was observed in 11.97% of participants, with 4.9% showing values ≥126 mg/dL. As for glycated hemoglobin, 80.28% had levels ≥5.4%, and 11.97% ≥6.5% (T2DM). These findings are consistent with previous studies in the region[25,29].

The finding that a significant fraction of undiagnosed individuals met biochemical criteria for prediabetes or T2DM underscores the effectiveness of FINDRISK as an initial filter, while also demonstrating the need for laboratory confirmation, following international recommendations[27]. Notably, 68.31% of patients had HbA1c levels compatible with prediabetes (5.4–6.4%), indicating a high proportion of individuals in a metabolically high-risk phase who could benefit from intensive preventive interventions.

Compared to international studies, the prevalence of glycemic disorders in the Paraguayan sample is similar to that of other countries in the region but higher than in some European populations, likely due to differences in dietary patterns, physical activity levels, and access to health services[28,30].

Hypertriglyceridemia was identified in 19.71% and low HDL cholesterol in 62.67%, with these alterations being more common among women with increased abdominal circumference. A total of 24.64% met the criteria for metabolic syndrome, with the most common combination being central obesity, elevated blood pressure, and high triglycerides.

This finding is relevant, as metabolic syndrome increases cardiovascular risk and complicates the clinical management of patients at risk for T2DM[31]. Its prevalence in this group supports the need for a comprehensive approach beyond glycemic control, encompassing lipid, blood pressure, and weight management. International literature emphasizes that the coexistence of metabolic syndrome and T2DM significantly increases the risk of cardiovascular complications, kidney failure, and premature mortality[27,32]. Early identification of these patients in primary care is essential for implementing multidimensional interventions and reducing long-term disease burden.

The study documents a trend associating higher FINDRISK scores with confirmed metabolic alterations, including cases meeting diagnostic criteria for T2DM. This supports the use of FINDRISK as a risk stratification tool and justifies its systematic implementation in primary care, especially in resource-limited settings[30,33]. However, it is important to acknowledge that FINDRISK's sensitivity and specificity may vary depending on the population and cut-off point used; therefore, periodic local validations and adjustments to risk thresholds are recommended[28,33].

International literature indicates that early intervention can reduce the incidence of T2DM by up to 58%[34], but longitudinal local studies are needed to confirm these benefits in the Paraguayan context. Another key issue is the sustainability and scalability of the FINDRISK screening strategy within Paraguay's healthcare system. Factors such as healthcare staff overload, lack of incentives, and population resistance to lifestyle changes may limit the strategy's actual impact[21,31]. Designing community-based interventions tailored to local realities and strengthening health personnel training in promoting healthy lifestyles are essential.

The results obtained are comparable to successful regional experiences[32,35], which demonstrated the effectiveness of community-based interventions focusing on screening and health promotion in reducing metabolic risk. However, the sustainability of these strategies depends on effective integration between primary care, specialized services, and community participation[36].

Comparisons with European and North American studies reveal that although the prevalence of metabolic risk factors and T2DM is high in Paraguay, implementing screening and prevention strategies in primary care can significantly help reduce disease burden and improve population health[28,30].

The implementation of the FINDRISK test, combined with clinical and laboratory evaluation, represents a cost-effective and replicable strategy for early T2DM risk detection in primary care. To maximize its impact, it is essential to train healthcare professionals, ensure access to basic biochemical tests, and develop community-based interventions adapted to local conditions.

Moreover, it is necessary to strengthen the coordination between different levels of care, promote active community involvement, and design public policies that address the social and structural determinants of metabolic risk[36,37]. Only through an integrated and sustained approach will it be possible to reduce the incidence and complications of T2DM in Paraguay and the region.

This study presents limitations: the cross-sectional design prevents establishing causal relationships or evaluating risk progression over time; the convenience sampling and focus on a single USF limit result representativeness; the lack of longitudinal follow-up prevents evaluating the real

impact of early detection on T2DM incidence; barriers and facilitators for healthy lifestyle adoption or the influence of social determinants are not explored in depth.

To advance the knowledge and prevention of T2DM in Paraguay and the region, it is recommended to conduct cohort studies to evaluate risk progression and intervention effectiveness after FINDRISK-based detection; expand the sample to include various regions, including rural and Indigenous areas; integrate the analysis of social, economic, and environmental determinants of risk; evaluate the acceptability, feasibility, and sustainability of FINDRISK implementation within the Paraguayan health system; and explore the impact of multisectoral community interventions in reducing metabolic risk.

An integrated analysis of the results demonstrates that the FINDRISK test, when complemented with laboratory evaluation, allows timely identification of individuals at risk for T2DM, facilitating the implementation of preventive strategies at the primary care level. However, its real impact will depend on its integration into multidimensional health policies that are sustained and adapted to local contexts. Future studies should address the identified limitations and explore the impact of long-term interventions on reducing the burden of T2DM.

Conclusions.

The results of this study demonstrate that the implementation of the FINDRISK test in primary care made it possible to timely identify a significant group of individuals with a moderate to very high risk of developing T2DM. Among these, a high prevalence of modifiable risk factors was observed, such as overweight/obesity, physical inactivity, and poor diet, as well as a considerable proportion of metabolic alterations and previously undiagnosed cases of prediabetes and diabetes confirmed through laboratory testing. Additionally, more than one-quarter of participants met the criteria for metabolic syndrome, which increases cardiovascular risk.

These findings confirm the usefulness and feasibility of the FINDRISK test as an initial screening tool at the primary care level. Its systematic use, accompanied by clinical and laboratory follow-up, can significantly contribute to early detection and the implementation of targeted preventive strategies, thereby improving community health and reducing the future burden of diabetes and its complications.

Conflict of Interest Statement:

None.

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