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First dual-frame telephone survey for non-communicable disease risk and protective factors: Methods and main findings from a central Brazilian state, 2022

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ABSTRACT

Objectives: To Describe the methodology used in the first risk factor survey for non-communicable diseases in Goiás, a central state of Brazil and identify differences in prevalence of risk and protective factors for chronic disease between landline and mobile phone users.
Study design: A cross-sectional study.
Methods: A cross-sectional study was conducted using telephone interviews via landlines and mobile phones. The Random-Digit Dialing probabilistic sampling method was used to select phone lines. The Rake method weighted the data and the hot deck technique imputed missing weight and height data. A total of 5018 individuals residing in Goiás were stratified by sex, age group, education level and health macro-regions. Operational, demographic characteristics and prevalence of risk factors were evaluated, with crude and adjusted prevalence ratios calculated using the Poisson regression model.
Results: Mobile telephony offered some operational advantages, while refusal rates were lower for landlines. Landline telephony underestimated men, adults and individuals with fewer years of schooling, while mobile's underestimated the elderly. Significant differences in prevalence were found for 16 indicators. Mobile phone users showed higher prevalence of risk factors, while landline's showed higher prevalence of protective factors.
Conclusion: The use of both landline and mobile telephony was necessary to ensure population representativeness. However, new strategies are needed to improve participation in future surveys.

1. Introduction

Telephone surveys in the health field are a common practice in several countries [1–9]. In Brazil, in recent decades, it has proven to be an important strategy for monitoring risk factors for non-communicable diseases [10]. Since 2006, the Ministry of Health has established a surveillance system for risk and protection factors for non-communicable diseases (Vigitel), conducted annually. These surveys have shown the magnitude of risk factors in the country and led to important intervention and monitoring policies [10]. However, data from Vigitel Brasil only refers to state capitals. And yet, given the size and diversity of Brazil, combined with significant changes in the telephony distribution across the country, this data may not fully reflect the reality within individual states [10–12].

Abbreviations: Vigitel, a Brazil's national system of risk factor for non-communicable disease; RDD, a Random Digit Dialing method; BMI, Body Mass Index; BRFSS, the American Behavioral Risk Factor Surveillance System; CI, Confidence Interval; CPR, Crude Prevalence Ratio; APR, Adjusted Prevalence Ratio.

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The use of telephone surveys has incorporated different strategies for participant selection, especially with the growing number of mobile phones users. Several countries have already included mobile phones in their national surveys, which has improved population representativeness in studies [3,4,8,13,14].

The high telephone coverage in Brazil has contributed to making telephone surveys an effective and efficient methodological option. In 2021, 97 % of households had access to either landline or mobile phone [12]. However, despite this growth, there has been a rapid migration from landline to mobile phones, impacting the representativeness of surveys that relying solely on landline telephony. In the same year in Brazil, mobile telephone covered 96.3 % of households while landline coverage was 15.6 % [12]. In the same year in Goiás, a central state of Brazil, mobile telephony coverage was 98.2 % and landline telephone coverage was 14.4 % of households [12].

Despite this change, mobile phones were only incorporated into the National survey sample in 2023 [11]. Nevertheless, there is still limited evidence on the feasibility and challenges of including mobile phones and expanding representativeness beyond capitals in Brazil. National surveys such as Vigitel have been limited to state capitals, leaving a gap regarding the broader state population and smaller areas. To address this, Goiás implemented its first statewide telephone survey for non-communicable diseases in 2022, using both landline and mobile phones and providing results for the five health macro-regions, leveraging high telephony coverage [12] and replacing less sustainable in-home interviews [15].

This study aims to describe the methodology used in the first telephone survey of risk and protective factors for non-communicable diseases in Goiás, focusing on the use of landline and mobile phones, and identify differences in prevalence between the two groups.

2. Methods

2.1. Sample

The study was conducted in the State of Goiás, which had an estimated population of 7,018,354 in 2022. [16]. The State is divided into five macro-regions and 18 health regions. The Human Development Index (HDI) in 2021 was 0,737 and the Gross domestic product (GDP) per capita was 34,522.53 [17,18].

The sample was stratified by health macro-region, sex, age group, and education level. It was designed to be representative of the adult population (aged 18 and older) of Goiás. The sample size was set at 1000 individuals per macro-region (totaling 5000), following the standard adopted by Vigitel Brasil, which is in line with World Health Organization recommendations for telephone surveys [19]. This sample size ensures a maximum sampling error of 3.1 percentage points and a 95 % confidence level for the estimation of prevalences [19]. The final sample consisted of 5018 individuals aged 18 and older residing in Goiás, with and without a landline or cell phone (Table 1). Although the target sample size was reached in most macro-regions, minor operational variations occurred (953–1050 individuals), as commonly observed in previous editions of the Vigitel survey, but these did not impact the precision or representativeness of the estimates [20].

The sample was equally drawn from landlines and mobile phones. Phone numbers were selected using probabilistic Random-Digit Dialing (RDD), which generates random numbers from all operators in the region, ensuring equal probability of selection and minimizing bias [21]. Selected numbers were validated by computer call. The sample was also stratified by demographic variables, as in Vigitel Brazil, to improve representativeness [21].

2.2. Participants

The sample included individuals aged 18 years and older, residing in municipalities within Goiás, with a landline or mobile phone, who agreed to participate in the research. Those who, at the time of the call, did not have the physical, mental or psychological conditions to answer the questionnaire, as well as non-residential line respondents or respondent who lived in another district outside the state of Goiás but who share the same telephone code for national calls, were excluded from the sample.

2.3. Data collection instrument

The questionnaire was based on the one used in the national survey of 2019 [20]. It comprised 97 mandatory questions and 7 conditional questions, divided into seven sections, covering personal identification: optional name (each individual received an automatic identification code); sociodemographic variables: age, sex, education level, race/color, marital status; pregnancy; dietary habits; risk and protective factors: overweight, obesity, driving license, physical activity, smoking, alcohol abuse consumption; health status evaluation; use of health services and reported morbidity: hypertension, diabetes and depression. The questionnaire also included questions about COVID-19 and vaccination. The final version of the questionnaire was validated through a pilot test with 50 interviews in two municipalities from another Federative Unit, to ensure no portion of the population of Goiás was excluded during the valid interviews.

2.4. Data collection

The data were collected by a company, contracted through bidding, by the State Department of Health. Computer Assisted Telephone Interviews were conducted from Monday to Sunday, including holidays, from 9 a.m. to 9 p.m. on weekdays and from 10 a.m. to 4 p.m. on weekends and holidays, for 3 months from January to April 2022. All calls were recorded and encrypted.

For mobile phone line, the line owner was interviewed. For landlines, all household residents were listed and one individual was randomly selected. If the selected individual was not at home, a callback was scheduled. After a minimum of six attempts on different days and times,

Table 1
Estimated population of residents in Goiás, aged 18 and over for the year 2022, HDI-M, GDP per capita by health macro-regions and sample size*.

Health Macro-region	Population (2022)[1]	Population 18 years and older	No. of municipalities (macro-region)	HDI-M[2]	GDP per capita[3]	Final Sample size[4]	Landline sample	Mobile sample
Central-west	2,340,061	1,930,361	72	0.70	24,477.1	1050	550	500
Central-north	1,136,123	1,023,595	60	0.69	24,414.2	953	452	501
Central-southeast	1,512,056	1,253,341	55	0.71	49,559.5	1014	503	511
Northeast	1,330,797	1,114,185	31	0.66	15,712.9	1000	500	500
Southwest	699,317	566,680	28	0.70	43,399.4	1001	501	500
TOTAL	**7,018,354**	**5,888,162**	**246**	-	-	**5018**	**2506**	**2512**

(1) Estimates made for the population aged 18 and older, for the year 2022 based on Brazilian Institute of Geography and Statistics (IBGE/Brasil) (2021); (2) Human Development Index; (3) Gross domestic product (4) The set sample size was 1000 individuals per macro-region. The final sample size was smaller in the Central-north macro-region due to the difficulty of finding households with a landline telephone in the region. However, the variantion did not affect the precision of the estimates.

with or without a scheduling, if the selected individual did not answer or was unavailable or refused to answer the questionnaire, the contact was recorded as a loss.

2.5. Data analysis

The data analysis accounted for weights for each sample, calculated to represent the study population. Post-stratification or weighting is used to mitigate the coverage bias, commonly found in telephone surveys [22,23]. The Rake method was used to calculate sample weights, aligning the sample distribution with the adult population of Goiás, regardless of telephone ownership. This adjustment was necessary because the sample was equally distributed between landline and mobile phones (50 % each), which does not reflect the actual distribution of telephone coverage in the population. This method assigns a weight to each sample individual to align the sample's distribution with the reference population's distribution. It uses population frequencies from various external sources and interpolates population variables for intercensal periods [22]. Variables such as sex, age group, education level and health macro-regions were used to build the sample weights.

Due to the missing data on weight and height – necessary for calculating the BMI (Body Mass Index) – with non-responses rates of 5.5 % for weight, 5.2 % for height and 7.7 % for both variables, the hot deck data imputation technique was used to ensure a consistent sample, especially for future trend analyses. This technique groups data before imputation, filling in missing data for a specific variable while maintaining sample variety and avoiding bias, crucial for predictive models. We adopted the same imputation technique used in the national survey [24,25].

Non-responses included non-answering valid phone calls, refusals and losses. To evaluate operational differences between landline and mobile telephony, some indicators were considered (Table 2), along with the sample distribution by sex, age group, education level and macro-region according to type of telephony (Table 3). To assess differences in risk and protective factors prevalence between individuals with landline and mobile telephony, 28 indicators were selected. Prevalence were estimated by phone type, with chi-square tests. To compare prevalence estimates between mobile and landline phone samples, both absolute and relative differences were calculated.

Absolute prevalence difference was calculated as the prevalence in the mobile sample minus the prevalence in the landline sample. Relative difference (variation) was calculated as the absolute difference divided by the prevalence in the landline sample, multiplied by 100: Relative difference (%) = [(Prevalence_mobile − Prevalence_landline)/Prevalence_landline] × 100. Lastly, crude prevalence ratios (CPR) and their respective 95 % confidence intervals (95 %CI) were presented. For variables with p-values <0.20 (this cutoff was chosen for further investigation due to potential associations that may be significant in the adjusted analysis), adjusted prevalence ratios (APR) and 95 %CI by sex, age group, education level and macro-region were estimated. Prevalence ratios were estimated using a Poisson Regression model with robust variance. All analyses considered a 5 % significance level and were conducted using the survey module for complex samples in Stata version 16.0.

Table 2
Operational indicators by type of telephony.

Indicator	Landline telephony		Mobile telephony	
	N	%	N	%
Number of phones generated by RDD	181,318	–	75,035	–
Number and percentage of electronically validated telephone lines	30,824	17.0	19,509	26.0
Number and percentage of eligible telephone lines*	5,23	17.0	4352	22,3
Number and percentage of respondents by type of telephony	2,506	49.9	2512	50.1
Refusal rate **	327	**6.3**	334	**7.7**
Response rate (success rate) ***	2506	**47.9**	2512	**57.7**
Loss rate ****	2397	**45.8**	1506	**34.6**
Media of Interview time, in minutes, including registration *****	16:39	–	16:30	–

(*) Lines of residents in the State of Goiás aged 18 and over enabled (existing line)/Number of telephones generated and validated.
(**) Number of individuals who refused to answer the questionnaire on the first call, ending the contact/Number of eligible telephone lines x 100.
(***) Amount of respondents/Number of eligible telephone lines x 100.
(****) Number of eligible individuals who did not refuse to answer the questionnaire on the first call, started or scheduled the interview for another time, but did not answer or did not complete the interview/Number of eligible telephone lines x 100.
(*****) Media of the total interview time, in minutes, including the initial part of the interviewer's introduction and the reading of the consent form.

Table 3
Distribution of the sample according to the type of telephony (landline and mobile) by sex, age group, years of schooling and health macro-regions.

Features	Type of Telephony					
	Landline		Mobile		Total	p-value
	N	%	N	%		
Sex						
Male	890	43.4	1159	56.6	2049	**<0.001**
Female	1616	54.4	1353	45.6	2969	
Age range						
18–24 years old	327	56.0	257	44.0	584	
25–34 years old	432	48.6	456	51.4	888	
35–44 years old	588	41.5	830	58.5	1418	
45–54 years old	410	45.0	501	55.0	911	**<0.001**
55–64 years old	299	50.9	288	49.1	587	
65 and over	450	71.4	180	28.6	630	
Level of Education (years of schooling)						
0–8 years	755	44.4	945	55.6	1700	
9–11 years	1004	52.7	900	47.3	1904	**<0.001**
12 and over	747	52.8	667	47.2	1414	
Macro-regions						
North-Central	452	47.4	501	52.6	953	
Midwest	550	52.4	500	47.6	1050	
Midwest-Southeast	503	49.6	511	50.4	1014	0.292
Northeast	500	50.0	500	50.0	1000	
Southwest	501	50.0	500	50.0	1001	
Total	**2506**	**49.9**	**2512**	**50.1**	**5018**	

X^2 test.

2.6. Ethical considerations

A free and informed consent form was read to participants at the start of the interview. Confidentiality was assured for all information provided, and participants could terminate the interview at any time, with all previously provided information being discarded. The research was approved by the Ethics Committee of the Federal University of Goiás under number CAAE 01806818.9.0000.5083.

3. Results

Operational indicators by landline and mobile phone are shown in Table 2. The percentage of validated telephone lines, eligible telephone lines, refusal rate and response rate were higher in the mobile phone sample. However, the loss rate and the interview duration were higher for landlines. The average cost per interview was R$137.11 (approximately US$ 25.00) with no difference in costs between landline and mobile lines.

There was equitable representation between landline and mobile phone users across health macro-regions. Women, individuals aged 18–24 and those 65 years or older were better represented in landline

sample, while men and adults aged 25–64 years were better represented in mobile phone sample. The elderly was the least represented in mobile phone interviews. Regarding education, individuals with fewer years of schooling were better represented in mobile phone sample (Table 3).

Fig. 1 presents the prevalence rates of risk and protective factors according to the type of telephony. Of the 28 indicators studied, 16 showed significant differences, with higher prevalence observed in mobile phone sample for smoking, heavy smoking, passive smoking at work, overweight, obesity, regular consumption of soda, consumption of ultra-processed foods, practice of physical activity during commuting, alcohol abuse consumption and driving after alcohol consumption. For landline phone sample, higher prevalence was observed for regular consumption of fruits and vegetables, insufficient physical activity, physical inactivity, daily screen time greater than 3 h, diabetes and having undergone a mammogram at least once in life. The greatest difference and variation were observed in the indicators for alcohol abusive consumption and heavy smoking respectively.

In the univariate analysis, differences in prevalence of 16 risk and protective factors remained significant according to phone type. After adjusting for sex, age group, education level and health macro-region, significant difference persisted for 10 risk and protective factors: smoking, passive smoking at work, obesity, regular consumption of soda, consumption of ultra-processed foods, practice of physical activity during commuting and alcohol abuse consumption – higher in the mobile sample, and regular consumption of beans, physical inactivity, and diabetes – higher in the landline phone sample (Fig. 2).

4. Discussion

The option for the RDD method for selecting both landline and mobile phone lines, rather than seeking user lists from telephone operators, was due to limitations in the latter, such as difficulty accessing and outdated user registers and a high number of duplicate mobile lines. Additionally, RDD is simple, low-cost, and currently one of the most widely used methods for telephone surveys [4,21,26].

In addition to the limitation of accessing up-to-date phone user databases, the RDD method offered several benefits, including the ability to control quotas for sex, age group and macro-regions and the reduced possibility of bias, since each telephone number has virtually the same probability of being selected for the sample [21]. This unified the random selection methodology for both landlines and mobile phone. Along with the data collection period during the first four months of the year allowed for a faster execution of data collection and timely delivery of initial results to health managers.

The use of mobile phones in health surveys has been widely used internationally [1–6,8,26–29]. The American Behavioral Risk Factor Surveillance System (BRFSS) incorporated mobile phones in 2009. Other national-level surveys have also incorporated both landline and mobile phones in varying proportions. Like this study, those surveys demonstrated benefits in population representativeness by including both landline and mobile phones users in the sample design [1,2,27,30].

Vigitel Goiás was the first statewide and macro-regional risk and protective factor survey for non-communicable diseases (NCDs) in Brazil to include both landline and mobile phones in its sample. The first study to assessing the feasibility of introducing mobile phones in the country concluded that, at that time, it was not feasible due to low coverage and high cost of mobile telephony [31]. However, after about 10 years, mobile telephony coverage increased dramatically and the cost went down significantly. As of early 2023, Brazil and Goiás had mobile phone densities of 103.7 and 116.3 lines per 100,000 inhabitants respectively, higher than the average for low and middle-income countries [5,32]. The cost of a minute of mobile phone calls dropped from US$0.19 in 1998 to US$0.07 - average cost nowadays [33], making mobile phones a viable option, in terms of both coverage and cost, compared to a decade ago. A more recent study in France even explored the possibility of phasing out landline entirely [8]. However, unlike that study, our found that it is still necessary to maintain both landline and mobile phones to better reflect the actual distribution of these telephone types in the population.

Despite the similar distribution of respondents between landline and

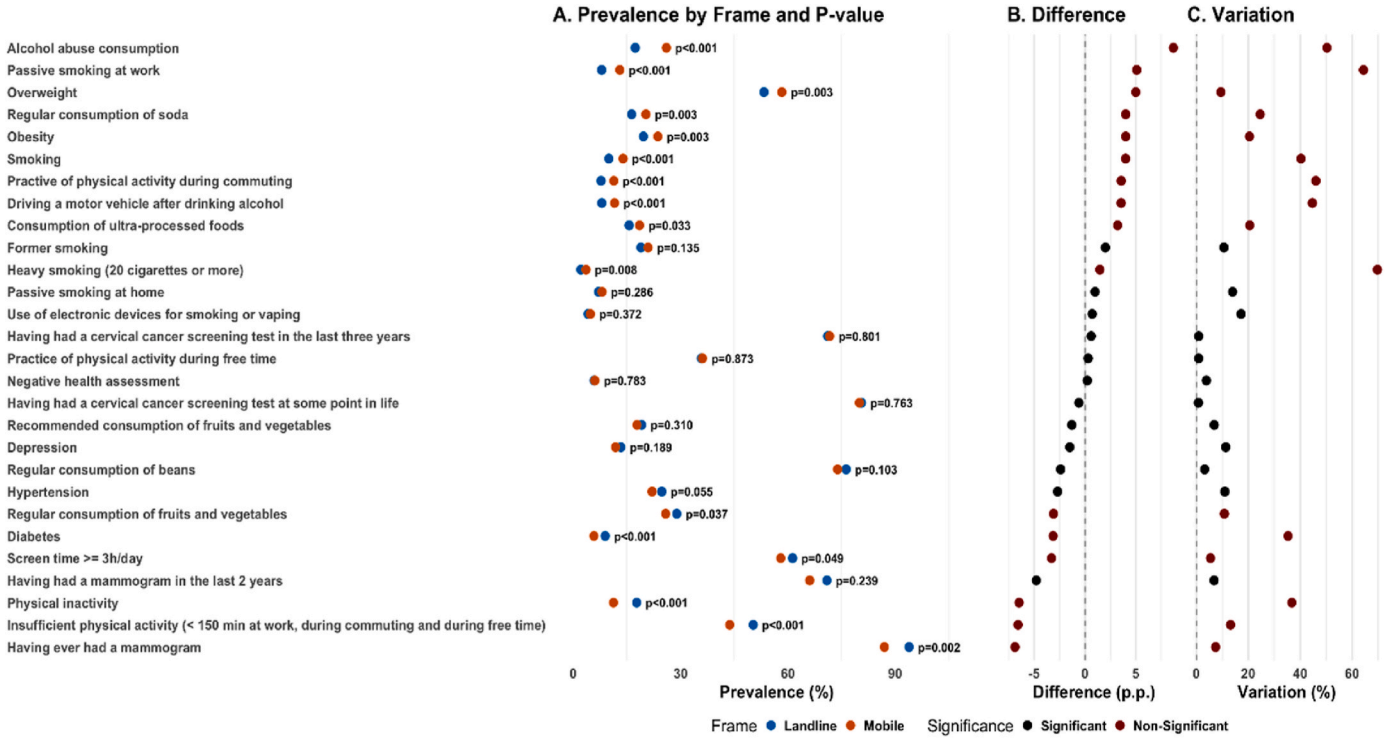

Fig. 1. Prevalence (%) of risk and protective factors and use of health services in the population with landline and mobile telephony, difference and percentage of variation*.

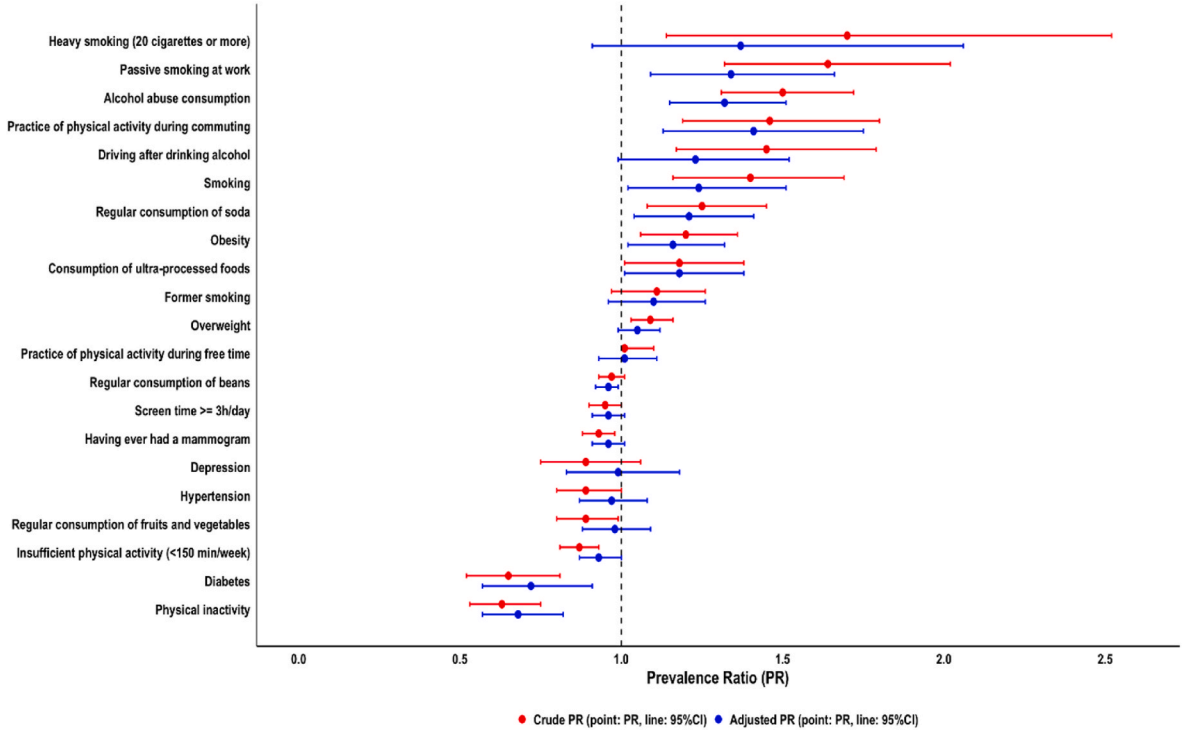

Fig. 2. Crude and adjusted prevalence ratio by sex, age group, education level and health macro-regions of risk and protective factors according to the type of telephony (landline and mobile).

mobile phone in our study – per the sample design – landline interviews were completed after mobile phone interviews, requiring an additional effort to meet the landline quota. This is because selecting individuals from landline households involves an additional step after the call is answered: a random selection of a household resident, who may not be the person answering the call. This required more effort to reach the selected individual. The economically active population was better represented in mobile interviews, while younger and older individual were better represented in landline interviews. This pattern of age group representation according to phone type is consistent with findings from other studies [2,7,8].

The greater representation of women in landline phone and men in mobile phone was expected and mirrors the patterns observed in other surveys [2,7]. The BRFSS, for example, has shown that mobile phones tend to better represented low-income individuals, men, minorities and young adults. In this study, mobile phones better represented the population with fewer years of schooling, which is expected due to the decreasing cost of mobile phones, increased supply, ease of acquisition and greater difficulty in maintaining a landline for among population without a fixed residence [2,4,33].

Regarding the differences in risk and protective factors prevalence between landline and mobile phone users, the variations are quite heterogeneous across different studies. However, most like this study, have found differences in prevalence rates even after weighting adjustments [1,2,4,8,23,27,34,35]. Generally, studies indicate an underestimation of risk behavior in surveys that rely solely on landline phones, with smoking being a risk factor that consistently shows a difference between landline and mobile phone users, appears in all studies evaluated with a difference between landline and mobile. The higher prevalence of risk factors among mobile phone users and the higher prevalence of protective factors among landline phone users observed in our study, align with findings from other studies [1,4,8,23,34,35]. This may be related to the social and economic distribution of the population by phone type. As previously discussed, the decreasing cost of mobile phone, along with increased coverage and the greater difficult of maintaining landline service, due to the lack of a fixed residence and practicality, has led to a migration from landline to mobile phones, particularly among poorer population, who are more vulnerable to the risk factors.

Despite the differences in the prevalence of risk and protection factors between the landline and mobile phone user samples in this and other studies and thus, the need to maintain both phone types in surveys to better represent the total population, the trend is that mobile phones will better represent the general population as mobile phone coverage continues to expand [4].

While telephone surveys are widely used for monitoring risk factors, gaining participation from the population has become increasingly challenging, with rising refusal rates and a consequent reduction in response rate [4,9,29,36,37]. This challenge can arise from various factors, such as participants' distrust in the authenticity of surveys, fear of scams, privacy concerns, lack of time to answer questions and the high volume of robocalls (automated phone calls). The refusal rate in our study was higher than that found in some editions of the national Vigitel survey [11,20] although that research did not include mobile telephony and close to the rate in some studies conducted in low-income countries [9], with a higher refusal rate among mobile phone respondents. This could be because mobile phones better represented economically active individuals, who may have been at work or engaged in other activities outside the home, making it harder to accept an interview.

Some strategies adopted in the survey in the State of Goiás may have helped control the refusal rate, such as promoting the survey on social media and television, support from regional and municipal coordinators, the provision and dissemination of an institutional phone number for inquiries, the option to withhold personal identification data, the ability to end the interview at any time, and prior validation of the questionnaire. Despite these efforts, the overall response rate was slightly above 50 %, and the loss rate was higher for landlines. High loss rates, as observed in this and other telephone surveys, may introduce non-response bias if non-respondents differ systematically from respondents. However, the application of post-stratification weights aimed to correct for such differences, and the final sample's

sociodemographic profile was similar to the target population. Nevertheless, this remains a limitation and should be considered when interpreting the results.

However, the declining response rate, which depends on both refusals and phone call pick-up rate, remains a major challenge in several countries conducting telephone surveys, including Brazil. In the first national Vigitel survey, in 2006, the response rate was 71 %, dropping to 34 % in 2023 [11]. In our study, the response rate was slightly above 50 %. In the BRFSS, it fell from 72 % in 1993, 51 % in 2006, 47 % in 2015, and have fallen significantly [36–39]. This challenge will require new strategies to engage the population in future telephone surveys or even new models of surveys, in which communication can be carried out, for example, through messaging applications, where acceptability, especially among younger people, is high. While mixed methodologies could cover the populations with less access to new technologies or even youngers [7].

Limitations of this study include the possibility of telephone coverage bias. While the sample weighting used in this study helps mitigate this type of bias, the equal distribution between landline and mobile phone in the sample differs from the population coverage. Furthermore, the sample size was set for operational reasons rather than estimated based on specific prevalence, which could affect the external validity of the results. To address this, post-stratification weighting was applied to align the sample with the sociodemographic structure of the adult population of Goiás, enhancing the external validity and generalizability of the findings. However, as with all telephone surveys, some residual coverage bias may remain, particularly among groups with limited telephone access. Although weighting can reduce this bias, it may not eliminate it entirely.

We conclude that the use of both landline and mobile telephony was necessary to ensure population representativeness in the telephone survey. While mobile phones offered some operational advantages over landlines, differences in the representativeness of population groups and the prevalence of risk and protective factors by phone type indicated the need to maintain both telephony in the sample design. Additionally, the notable refusal and non-response rates will require new strategies in the future to ensure population participation in telephone surveys. Improving the survey methodology will facilitate its execution, ensure population participation and representativeness and sustain it as a risk factor surveillance strategy in the state.

Ethical statement

A free and informed consent form was read to participants at the start of the interview. Confidentiality was assured for all information provided, and participants could terminate the interview at any time, with all previously provided information being discarded. The research was approved by the Ethics Committee of the Federal University of Goiás under number CAAE 01806818.9.0000.5083.

Availability of data and material

The data is not yet available in a repository. If necessary, please contact the author.

Declaration of generative AI in scientific writing

The author declares that no generative artificial intelligence (AI) or AI-assisted technologies were used in the writing process of this manuscript.

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Declaration of competing interest

The authors declare that they are not aware of competing financial interests or personal relationships that may have influenced the work reported in this article.

This manuscript has not been published previously and is not under consideration in any other Journal.

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Appendix A. Supplementary data

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