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SENSITIVITY AND SPECIFICITY OF A NEW TOOL FOR EARLY DETECTION OF RISK FACTORS FOR NON COMMUNICABLE DISEASES IN URBAN WORKERS

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ABSTRACT

Introduction: Non communicable diseases (NCDs) have an impact on health, economy, and quality of life, and can reduce worker productivity. Approximately 41 million people die from NCDs every year, accounting for 74% of deaths worldwide. The Deteksi Dini Faktor Risiko Gizi dan Kesehatan (DDR-GizKes) is instrument designed for the early detection of nutritional and health risk factors related to NCDs that affect the productivity of urban workers . A screening test is essential part of this newly developed tool. **Aims:** This study aims to test the sensitivity and specificity of the DDR-GizKes instrument for detecting NCDs in urban workers. **Methods:** This study used a descriptive observational design with a cross-sectional approach. The population consisted of 227 teachers and staff in high schools in Yogyakarta who were selected using a cluster random sampling technique. Hypertension was used as the gold standard for the screening test. **Results:** The nutritional risk factor test had a sensitivity of 15.8% and a specificity of 94.2%. The positive predictive value (PPV) for the nutritional risk factor was 16.7% and the negative predictive value (NPV) was 93.8%. Meanwhile, the health risk factor test had a sensitivity of 15.8% and a specificity of 86.4%. The PPV for the health risk factor was 7.89% and the NPV was 93.3%. **Conclusion:** The DDR-GizKes instrument had low sensitivity but high specificity. Further research is necessary to establish the scoring system of the DDR-GizKes instrument in populations with a high prevalence of NCDs using a larger sample size.

Keywords **:** Nutrition , Health , DDR-GizKes , NCDs , Workers

INTRODUCTION

Nonc ommunicable d iseases (NCDs) have an impact on the health, economy, and quality life of patients, families and communities (Rijal et al., 2019), reduce worker productivity (H et al., 2021) , and place a burden on the healthcare system (World Health Organization, 2023b). Approximately 41 million people die from NCDs , accounting for 74% of deaths worldwide (World Health Organization, 2023b). The emergence of various NCDs, such as chronic obstructive pulmonary disease, cardiovascular disease, diabetes mellitus, and cancer, increases the burden of medical costs for patients and society (Kazibwe et al., 2021) . Workers who are frequently sick or absent from work may impede the achievement of organizational goals, resulting in losses that also affect the national economy (World Health Organization, 2019). NCDs are the leading cause of mortality and morbidity worldwide (Tolonen et al., 2023).

The prevalence of NCDs in Indonesia, including hypertension, stroke, cancer, chronic kidney disease, and diabetes mellitus, has increased from 2013 to 2018 (Ministry of Health, 2019). In the Special Region of Yogyakarta Province, the prevalence of NCDs such as diabetes mellitus and hypertension is also on the rise (Health Office of the Special Region of Yogyakarta, 2022). High blood pressure, also known as hypertension, is the most common risk factor for NCDs (Gupta and Xavier, 2018; Fuchs and Whelton, 2020). Hypertension affects approximately 1.28 billion people globally between the ages of 30 and 79 with the majority, or two-thirds, residing in low- and middle-income countries.

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One of the global goals for NCDs is to decrease the prevalence of hypertension by 33% by 2030 (World Health Organization, 2023a).

In recent years, the prevalence of NCDs has increased due to rising economic status, changes in lifestyle, and the effects of modernization (Ismail and Sivadas, 2020) . Risk factors of non-communicable diseases have also increased, including unhealthy eating patterns, lack of physical exercise, dangerous alcohol use, and exposure to tobacco smoke (Ministry of Health, 2019). The lifestyle of workers can also contribute to the development of NCDs , such as low physical activity and bad eating habits, including skipping breakfast, frequent snacking , consuming junk food, and eating few fruits and vegetables (Idris et al., 2021) . Therefore, it is important to screen individuals at a productive age who are healthy or at risk of NCDs on a regular basis. In addition, early detection of risk factors is essential for disease prevention . Previous research has developed a risk self-assessment tool called *Deteksi Dini Faktor Risiko Gizi dan Kesehatan* (DDR-GizKes). The DDR-GizKes is an instrument in the form of a questionnaire designed for early detection of nutritional and health risk factors related to NCDs that affect the productivity of urban workers (Nai et al., 2023) . A screening test is an essential part of this newly developed tool . Sensitivity and specificity analy ses are commonly used to evaluate screening studies (Bujang and Adnan, 2016) .

This study aims to address the problem of NCDs by evaluating the sensitivity and specificity of the DDR-GizKes instrument, which is designed for early detection of NCDs in urban workers. The key elements in the management of NCDs are detection, screening, and treatment (World Health Organization, 2023b). The DDR-GizKes instrument has been assessed for content validity by a panel of occupational nutrition experts and face validity by twenty employees with acceptable reliability. These validation did not include measuring sensitivity and specificity (Nai et al., 2023) . However, these validations did not include the evaluation of sensitivity and specificity of the DDR-GizKes instrument in comparison with the gold standard, which is crucial before applying this instrument to urban workers. In this study, hypertension was used as the gold standard for the DDR-GizKes instrument screening test. The incidence of hypertension is higher in individuals with cardiovascular disease and other serious illnesses (Gupta and Xavier, 2018) . Therefore, detecting hypertension is critical to prevent the emergence of other NCDs . The novelty of this study is the assessment of the sensitivity and specificity of the DDR-GizKes instrument, which has not been previously evaluated (Nai et al., 2023) . Therefore, this study aims to evaluate the sensitivity and specificity of the DDR-GizKes instrument for detecting NCDs in urban workers.

METHODS

Design, Location, and Time

This study used a descriptive observational design with a cross-sectional approach. This study was conducted in a number of senior high schools and vocational high schools in Yogyakarta City from July to October 2023.

Population, Sample Size, and Sampling Method

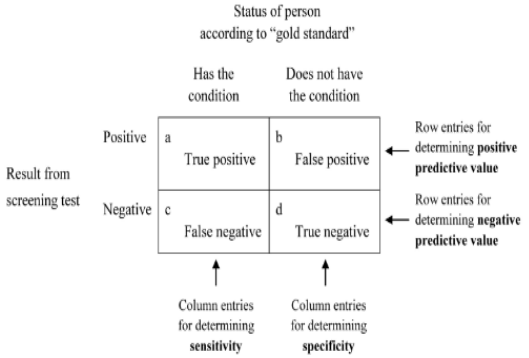
The population consisted of teachers and staff in a number of senior high schools and vocational high schools in Yogyakarta City who met the inclusion criteria. The participants were required to be between 20 and 40 years , willing to participate by signing informed consent, not currently on a certain diet, and not pregnant (for female participants). The sample size for the screening test was determined based on the Sample Size

Calculation for Sensitivity and Specificity Analysis for Disease Prevalence of 5% to 20%. The estimated prevalence of hypertension in urban workers is 20%. The null hypothesis (H0) is 0.50 and the alternative hypothesis (Ha) is 0.60. The power is 0.804 and the p-value is 0.047. T he minimum sample size required for positive disease is 50. In this study , the minimum sample size required was 249 participants (Bujang and Adnan, 2016) . Ultimately, 277 participants who provided complete data were involved in this study .

The participants were selected using a cluster random sampling technique . The study was conducted in 72 senior high schools and vocational high schools in Yogyakarta City during the 2022/ 2023 semester (Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia, 2023) . The number of clusters was determined to be 14 schools, which is 20% of the total clusters (Nugraeni et al., 2023) . Out of the 14 schools, the selected clusters were schools that gave permission to conduct this study and me t the minimum sample size. Nine high schools selected as clusters, namely 1 State Senior High School, 2 State Senior High School, 7 State Senior High School, 11 State Senior High School, 2 State Vocational High School, 3 State Vocational High School, 4 State Vocational High School, Pangudi Luhur Senior High School, and Bintang Timur Catholic Senior High School. Teachers and staff in each school who met the inclusion criteria were involved in this study.

Variables

This study focuses on three main variables , namely sensitivity, specificity, and hypertension. Sensitivity is the proportion of positive test results among individuals who have the disease or the ability of the test to correctly identify those with the disease. Specificity is the proportion of negative test results among individuals who do not have the disease or the ability of the test to correctly identify those without the disease (Swift et al., 2020) . A 2x2 table was used to calculate sensitivity and specificity .



$$\text{Sensitivity} = [a / (a + c)] \times 100$$
$$\text{Specificity} = [d / (b + d)] \times 100$$
$$\text{Positive predictive value (PPV)} = [a / (a + b)] \times 100$$
$$\text{Negative predictive value (NPV)} = [d / (c + d)] \times 100.$$

Figure 1 .Calculation of Sensitivity, Specificity, PPV, and NPV (Trevethan, 2017)

Sensitivity and specificity tests were conducted on the DDR-GizKes instrument to evaluate nutritional and health risk factors . The DDR-GizKes instrument includes question items about risk factors for health and nutrition. There are 18 indicators for assessing NCDs in relation to nutritional risk factors and four indicators in relation to health risk factors . Each indicator is assigned a score of 0 to 10. A score of 10 indicates a category that is at risk for NCDs . The total score is the sum of all indicator scores for nutritional and health risk factors. The cut-off points for nutritional and health risk factors for detecting NCDs are 91 and 22, respectively. A nutritional risk factor score of 91 and higher and a health risk factor score of 22 and higher indicate a risk of developing NCDs (Nai et al., 2023) .

The gold standard for the screening test in this study was hypertension with a blood pressure value 140/90 mmHg or greater (Ministry of Health, 2019). The blood pressure was measured using a sphygmomanometer.

The data collected from the participants included age range (20-30 years and 31-40 years), sex , education level (elementary school dropout, elementary school, junior high school, senior high school, diploma, bachelor's degree, master's degree, and doctorate degree), income level (<IDR1,900,000, IDR 1,900,001 -3,800,000, IDR3,800,001- 5,700,000, IDR5,700,001-7,600,000, and >IDR7,600,000), and marital status (married, single, or divorced). The characteristics of the participants were collected using a structured questionnaire.

Data Collection

The data were collected by distributing the DDR-GizKes instrument and carrying out a physical examination. The characteristics of the participants were collected using a semi-structured questionnaire. A physical examination was carried out to collect data on blood pressure and question items in the DDR-GizKes instrument, including body weight, height, abdominal circumference, waist circumference, and hip circumference. The DDR-GizKes instrument was filled in directly by the participants with the assistance of an enumerator prior to taking the blood pressure measurement to prevent any influence from the results of the blood pressure measurement . This study involved 17 students as enumerators from the Nutrition S tudy P rogram and N ursing Study Program at Sekolah Tinggi Ilmu Kesehatan Panti Rapih Yogyakarta. The enumerators were trained in physical measurement and administration of the DDR-GizKes instrument.

Data Analysis

The data were analyzed using univariate analysis and screening tests. Univariate analysis was performed to describe the characteristics of the participants. Screening tests were carried out to analyze sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). STATA version 13 was used for the data analysis.

Ethical Approval

This study received approval from the Ethics Committee for Health Research of the Faculty of Health Science of Respati University of Yogyakarta with a certificate number 0145.3/FIKES/PL/VII/2023 . Data collection in each school was carried out after obtaining permission from the school authorities. Informed consent was obtained from the participants prior to their participation in this study .

RESULTS

This study involved 227 participants . According to Table 1, the majority of the participants were aged between 31 and 40 years (57.4%), males (50.9%), and had a bachelor's degree (69.6%). In addition, the majority of the participants were married (69.3%) and had an income of between IDR1,900,001 and IDR3,800,000 (73.3%).

Table 1. Characteristics of the participants

Variable	Frequency	%
Age		
20- 30 years	**118**	**42.6**
31- 40 years	**159**	**57.4**
Sex		
Male	**141**	**50.9**
Female	**136**	**49.1**
Education Level		

Variable	Frequency	%
Elementary school dropout	**3**	**1.1**
Elementary school	**1**	**0.4**
Junior high school	**1**	**0.4**
Senior high school	**41**	**14.8**
Diploma	**12**	**4.3**
Bachelor's degree	**193**	**69.6**
Master's degree	**26**	**9.4**
Doctorate degree	**0**	**0.0**
Income Level		
< IDR 1,900,000	**32**	**11.5**
IDR 1,900,001- 3,800,000	**203**	**73.3**
IDR 3,800,001- 5,700,000	**31**	**11.2**
IDR 5,700,001- 7,600,000	**8**	**2.9**
>IDR7,600,000	**3**	**1.1**
Marital Status		
Married	**192**	**69.3**
Single/divorced	**85**	**30.7**
Total	**277**	**100.0**

Table 2. Sensitivity, specificity, PPV, and NPV of nutritional and health risk factors of the DDR-GizKes instrument

Parameters	Nutritional Factor	Health Factor
Prevalence : 6.9%		
True Positive	3	3
False Negative	16	16
True Negative	243	223
False Positive	15	35
Sensitivity	15.8%	15.8%
Specificity	94.2%	86.4%
Positive Likelihood Ratio	2.72	1.16
Negative Likelihood Ratio	0.89	0.97
Positive Predictive Value (PPV)	16.7%	7.89%
Negative Predictive Value (NPV)	93.8%	93.3%

Table 3. Comparison of area under the curve for nutrition and health risk factors

Variables	Area Under the Curve				
	Area	95% Confidence interval		Standard Error	p
		Lower Bound	Upper Bound		
Nutritional Factor	0.671	0.544	0.798	0.0647	0.004
Health Factor	0.402	0.263	0.540	0.071	

Table 2 shows that the prevalence of hypertension in the urban working population is 6.9%. The sensitivity test result for nutritional risk factors is 15.8%, indicating the ability of the nutritional risk factor test to yield positive results among urban workers who experienced hypertension is 15.8%. Meanwhile, while the remaining rest results are negative (false negative). In comparison, the specificity test result for the nutritional risk factors is 94.2%, indicating that the ability of the nutritional risk factor test to yield negative results among urban workers who did not experience hypertension is 94.2%. Meanwhile , the remaining test results are positive (false positive). Furthermore, the positive predictive value (PPV) of the nutritional risk factor test for the prevalence of hypertension in urban workers is 16.7%, indicating that the true probability of experiencing hypertension if the nutritional risk factor test result is positive is 16.7%. In comparison, the negative predictive value (NPV) of the nutritional risk factor test for the prevalence of hypertension in urban workers is 93.8%, indicating that the true probability of not experiencing hypertension if the nutritional risk factor test result is negative is 93.8%.

Moreover, the sensitivity test result of the health risk factor test is 15.8%, indicating that the ability of the health risk factor test to yield positive results among urban workers with hypertension is 15.8%, while the remaining test results are negative (false negative). In contrast, the specificity test result of the health risk factor test is 86.4%, indicating that the ability of the health risk factor test to yield negative results among urban workers without hypertension is 86.4%, while the remaining test results are positive (false positive). The positive predictive value (PPV) of the health risk factor test for the prevalence of hypertension in urban workers is 7.89%, indicating that the true probability of experiencing hypertension if the health risk factor test result is positive is 7.89%. In contrast, the negative predictive value (NPV) of the health risk factor test for the prevalence of hypertension in urban workers is 93.3%, indicating that the true probability of not experiencing hypertension if the health risk factor test result is negative is 93.3%.

Based on Table 3, Figure 2, and Figure 3, the area under the curve for the nutritional risk factor test is 0.671 (0.544 - 0.798) and for the health risk factor test was 0.402 (0.263 - 0.540) with a p-value of 0.004. Using a significance level (α) at 0.05, the ability of the nutritional and health risk factor tests to detect hypertension as the gold standard is different.

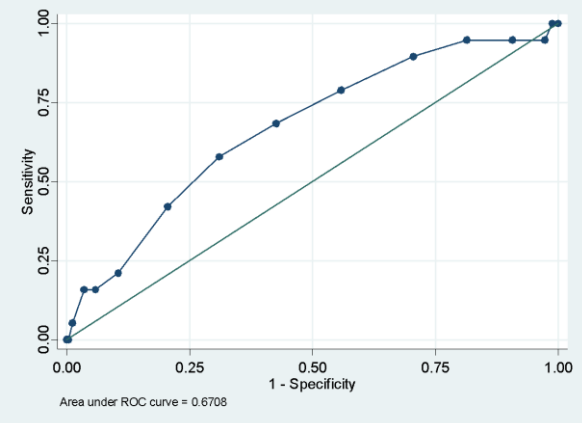


Figure 2. Area under the C urve of the Nutritional Risk F actor

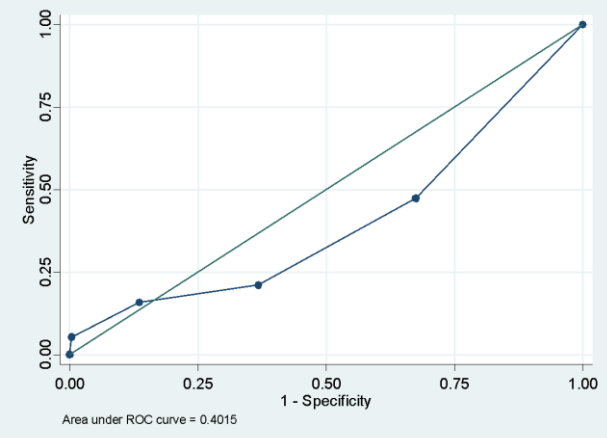


Figure 3. Area under the Curve of the Health Risk Factor

DISCUSSION

This study aims to evaluate the *Deteksi Dini Faktor Risiko Gizi dan Kesehatan* (DDR-GizKes) instrument which has been developed and tested for content and face validity and reliability in previous research with good and acceptable results (Nai et al., 2023). In previous research, the DDR-GizKes instrument was developed based on theoretical insights regarding nutritional and health risk factors related to NCDs that can affect the productivity of urban workers. In this study, a scoring system was developed for each indicator of nutrition and health risk factors for early detection of NCDs in urban workers (Nai et al., 2023).

This study assessed the sensitivity and specificity of the DDR-GizKes instrument for early detection of NCDs in urban workers based on an established scoring system, specifically hypertension, using blood pressure measurement as the gold standard with a sphygmomanometer. The scoring system can be used to detect hypertension (Hatmalyakin et al., 2023) . Previous research has developed a scoring system to predict the incidence of hypertension in the productive age group (Firmansyah et al., 2020). The DDR-GizKes instrument scoring system is differentiated for nutritional and health risk factors to detect NCDs. It includes 14 sub-variables and 18 indicators of nutritional risk factors, as well as six sub-variables and six indicators of health risk factors . To create the first DDR-GizKes instrument, 63 indicators were derived , 28 of which were related to nutritional risk factors and 35 to health risk factors. The total score for the nutritional risk factors was 145, which was the maximum score. Meanwhile, the total score for the health risk factors was 40, which was the total score of the four indicators (Nai et al., 2023).

The results of this study suggested that the sensitivity value for nutritional and health risk factors is low, while the specificity value is high. In addition, the positive predictive value (PPV) for nutritional and health risk factors is low, while the negative predictive value (NPV) is high. A screening test is considered beneficial to public health if it can identify individuals at high risk of several NCDs with a sensitivity of at least 75% and a specificity of at least 65%.(Gupta et al., 2017). Sensitivity and specificity indicate how well a test performs in comparison to the results from gold standards. On the other hand, the PPV and NPV indicate the effectiveness of a test in classifying individuals as having or not having the target condition based on the test findings (Trevethan, 2017).

The prevalence of a disease in a population can affect the sensitivity, specificity, PPV, and NPV of a screening tool (Hajian-Tilaki, 2014; Gogtay and Thatte, 2017; Trevethan, 2017) as well as the sample size (Bujang and Adnan, 2016). The prevalence of a disease varies from one population to another (Bujang and Adnan, 2016). A higher disease prevalence can result in higher sensitivity values and lower specificity values (Murad et al., 2023). In a population with a higher disease prevalence, the NPV is higher due to false positive results (Swift et al., 2020). Therefore, screening tests are carried out in populations with a higher risk of disease to reduce false positive results and increase the NPV (Bujang and Adnan, 2016).

This study examines the prevalence of hypertension in the urban working population . This study was conducted on urban workers due to their higher likelihood of nutritional and health risk factors related to NCDs (Idris et al., 2021). In addition, the age range for this study was between 20 and 40 years. Previous research shows that the incidence of hypertension is more prevalent among individuals aged between 50 and 60 years compared to younger individuals (Mularum et al., 2018). Moreover, age and blood pressure are positively correlated

(Caraballo et al., 2021). Due to a number of anatomical and physiological modifications, the prevalence of hypertension steadily increases with age (Jung et al., 2019). For individuals aged above 40 years, hypertension screening may be necessary if there is a growing trend in systolic blood pressure (Cheng et al., 2022). However, even tests with relatively high sensitivity and specificity may have low positive predictive value if the population prevalence is low . Therefore, to assess screening tests, it is also necessary to evaluate both the technical and population characteristics (Maxim et al., 2014). As a result, the DDR-GizKes instrument to be less sensitive in detecting NCDs in individuals aged under 50 years.

The prevalence of a disease affects the minimum sample size required for screening and diagnostic tests. Larger samples are necessary to detect higher levels of sensitivity for diseases with lower prevalence as well as higher levels of specificity for diseases with higher prevalence (Bujang and Adnan, 2016). Adequate sample size is the basis for determining the specificity and sensitivity of screening tests (Maxim et al., 2014). This study involved 277 participants for the DDR-GizKes instrument screening test, which is a relatively large sample. However, to achieve higher sensitivity and specificity, further research could include a larger sample size . The sensitivity and specificity of most screening tests can be determined with a minimum sample size of 300 individuals (Bujang and Adnan, 2016).

The DDR-GizKes instrument scoring system for predicting the risk of NCDs in urban workers also affects the level of sensitivity and specificity. The cut-off points for nutritional and health risk factors for NCD risk grouping may need to be re evaluated because sensitivity and specificity vary depending on the cut-off points . Specificity and sensitivity are negatively correlated, indicating that when sensitivity increases , specificity decreases, and vice versa. A threshold that prioritizes true negatives will result in more false negatives. Similarly, a threshold that prioritizes false positives will result in more true positives (Gogtay and Thatte, 2017).

In addition, the scoring of several indicators of nutritional and health risk factors can be modified . For example, regularly skipping breakfast increases the risk of developing NCDs and is assigned a score of 10. Skipping breakfast has been associated with overweight and obesity (Wicherski et al., 2021), which in turn can impact the regulation or metabolism of the body, ultimately affecting weight management (Gibney et al., 2018). Meanwhile, obesity is a major contributor to serious NCDs (Zatońska et al., 2021). Moreover, insufficient sleep less than seven hours per night has been associated with an increased risk of NCDs (Mularum et al., 2018; Nurpratiwi et al., 2023). Therefore, this category is assigned a score of 10.

Changes in the scores for several indicators can alter the score range for nutritional and health risk factors. It is necessary to develop a scoring system to add the nutritional and health risk factor scores for the DDR-GizKes instrument. Therefore, further research is needed to develop the DDR-GizKes instrument scoring system for urban working populations with a more diverse age range. In addition , the gold standard should not only include the incidence of hypertension, but also the detection of NCDs with a high prevalence in urban workers, such as diabetes mellitus or coronary heart disease (Kuruvilla et al., 2023) . For this reason, the research can use a case-control or prospective cohort design.

The results of the screening tests for the nutritional and health risk factors of the DDR-GizKes instrument indicated low sensitivity and high specificity. In conditions where funds and experts for diagnostic procedures are limited,

screening tools with high specificity are necessary to reduce disease prevalence (Gupta et al., 2017). Therfore , screening tests are carried out on individuals who are most likely to be ill to minimize false positives. The DDR-GizKes instrument is a screening tool for NCDs that is cheap, user-friendly , safe , and reliable . The indicators of the nutritional and health risk factors for the DDR- GizKes instrument to detect NCDs should be developed based on the balanced nutrition guidelines for the Indonesian society.

Limitations

One limitation of this study is that the population consisted of a young age group, namely individuals aged between 20 and 40 years , who have lower risk of hypertension compared to those above 40 years . In addition, the prevalence of hypertension in the urban working population is un known, which may affect the sensitivity value. Furthermore, the NCDs studied only included hypertension. Although the sample size of this study met the required criteria , the sample size for the DDR-GizKes screening test still needs to be increased.

CONCLUSION

The DDR-GizKes instrument has been found to have low sensitivity and high specificity. Further investigation is required to evaluate its scoring system in urban worker populations with a high prevalence of NCDs using a larger sample size.

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