

Identifying, Measuring, and Ranking Social Determinants of Health for Health Promotion Interventions Targeting Informal Settlement Residents

Farhad Nosrati Nejad¹, Mohammad Reza Ghamari², Seyed Hossein Mohaqeqi Kamal³, Seyed Saeed Tabatabaee^{4,5}

¹Social Determinants of Health Research Center, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran; ²Department of Social Welfare Management, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran; ³Social Welfare Management Research Center, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran; ⁴Social Determinants of Health Research Center, Mashhad University of Medical Sciences, Mashhad, Iran; ⁵Department of Health Economics and Management Sciences, School of Health, Mashhad University of Medical Sciences, Mashhad, Iran

Objectives: Considering the importance of social determinants of health (SDHs) in promoting the health of residents of informal settlements and their diversity, abundance, and breadth, this study aimed to identify, measure, and rank SDHs for health promotion interventions targeting informal settlement residents in a metropolitan area in Iran.

Methods: Using a hybrid method, this study was conducted in 3 phases from 2019 to 2020. SDHs were identified by reviewing studies and using the Delphi method. To examine the SDHs among informal settlement residents, a cross-sectional analysis was conducted using researcher-made questionnaires. Multilayer perceptron analysis using an artificial neural network was used to rank the SDHs by priority.

Results: Of the 96 determinants identified in the first phase of the study, 43 were examined, and 15 were identified as high-priority SDHs for use in health-promotion interventions for informal settlement residents in the study area. They included individual health literacy, nutrition, occupational factors, housing-related factors, and access to public resources.

Conclusions: Since identifying and addressing SDHs could improve health justice and mitigate the poor health status of settlement residents, ranking these determinants by priority using artificial intelligence will enable policymakers to improve the health of settlement residents through interventions targeting the most important SDHs.

Key words: Social determinants of health, Poverty areas, Developing countries, Slums

INTRODUCTION

According to international organizations, about 32% of people (over 1 billion) in urban communities live in informal settlements. The number of those living in informal urban settlements has increased globally since the 1990s, and the total population of settlement residents is expected to reach more than 2 billion by 2030 [1]. In Iran, urbanization has also increased rapidly in recent decades. One consequence of this rapid growth has been an increase in the number and size of informal settle-

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Corresponding author: Mohammad Reza Ghamari
Department of Social Welfare Management, University of Social Welfare and Rehabilitation Sciences, Tehran 0098, Iran

E-mail: mrg1400@gmail.com

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ments in metropolitan areas [2].

The United Nations Center for Human Settlements defines an informal settlement as a time-worn city area with low-quality housing construction, unsafe residential environments, pollution, excessive congestion, and insufficient basic facilities [3]. Research has shown that the health status of slum residents is very poor compared to residents of nearby urban areas, and residents of these areas face many health challenges [4,5].

Overcrowding and a lack of infrastructure and sanitation systems create dangerous conditions for people's health [6]. Children and families in informal settlements are widely exposed to poor social and health conditions. The abundance of problems in these areas could endanger the physical, mental, and social health of their inhabitants [7].

According to World Health Organization regulations and many international treaties, reducing injustice in health outcomes is a moral imperative, and access to the highest standard level of health care is a human right; therefore, given the large population of those who live in informal urban settlements, addressing the health status of these residents and eliminating injustice rooted in previous programs and policies are undeniable necessities. Therefore, particular attention should be given to the health of the inhabitants of informal settlements, since their health outcomes cannot be improved at the point of care alone [8].

Basic and essential measures must be taken to improve the health of informal settlement residents. Substantial evidence shows that socioeconomic factors play a key role in determining the health status of individuals and societies, and these factors are referred to as social determinants of health (SDHs). The concept of SDHs refers to factors that contribute to people's health before they become sick and require special care services. Ignoring these factors makes it impossible to achieve the primary goals of the health sector and establish justice in health [9,10].

Various studies have emphasized the importance of SDHs in the emergence of new diseases and the design of interventions aimed at health promotion. For example, Pawar et al. [11] observed that interventions designed to promote the health of informal settlement residents should be based on a strong understanding of health determinants. Like physical factors, social factors also play an important role in determining health status and devising appropriate interventions. Policy-making and planning that consider SDHs, such as income, education, housing, food, social security, and other factors, could have

positive long-term effects on people's health [12].

Although residents of informal settlements share many features with the general population, such as serious health challenges, they differ in terms of living conditions and social and political factors [13]. Therefore, in order to improve the health of those who live in different cities and places, the SDHs of specific populations must be considered by policymakers.

Considering the large number, diversity, and scope of SDHs, the researchers in this study aimed to conduct a case study in a metropolitan area in Iran to determine which SDHs would most improve the health status of settlement residents so that they can be prioritized when designing health-promotion intervention programs to be implemented in these areas. Given the lack of sufficient evidence-based research on this subject, the results of this study could be used as a basis for designing health promotion interventions by planners and policymakers in the particular metropolitan area, as well as those in other developing countries and informal settlements.

METHODS

Using a hybrid method (qualitative and quantitative), this exploratory study was conducted in 3 phases from late 2019 to the end of 2020.

First Phase

First, a scoping review was conducted, and a list of SDHs of informal settlement residents, which included 87 determinants across 7 dimensions, was prepared. The article presenting those findings has been published and is available for reference [14].

Second Phase (Delphi Method)

In order to complete the list of SDHs and confirm the accuracy of the SDHs identified in the first stage, the list was shared with 20 experts, who were selected using the purposeful sampling method, to obtain their opinions. The experts in this study included 7 social medicine specialists, 6 health educators, and 7 experts from different organizations that employ physicians and professionals who work in informal settlements. All the experts had at least 5 years of experience in scientific or practical activities in the field of health services. This stage was performed in 3 rounds according to the Delphi method. In the first and second rounds, the list of SDHs of informal settlement residents was completed, and after achieving a consensus between the experts, the number of SDHs in-

creased to 96. Since the SDHs that could be used in interventions have a substantial impact on health and should be given more attention [10], in the third round of the Delphi method, the SDHs identified in the first and second rounds were placed in a table and studied based on 2 indicators: modifiability by measures (rated on a 3-point scale with possible answers of "agree," "disagree," and "no opinion") and importance to residents' health (rated on a scale of 1 to 5). The opinions of the experts were then obtained based on this table. After summarizing and calculating the results, the mean scores for the opinions of the 20 experts were determined and tested using the 1-tailed Student's *t*-test with *p*-values. Based on the *p*-values from this test, the consensus of the group of experts and the presence of SDHs in the final list could be examined for the entire statistical population.

Third Phase (Cross-sectional Study)

In the third stage, to assess the status of each determinant selected in the previous stage and to assess the health status of residents in the statistical population, a cross-sectional study was conducted.

Research population

The statistical population of this study consisted of individuals who lived in informal settlements in a single metropolitan area. The total population of the informal settlements included in this study was approximately 922 000 people, including approximately 180 000 families in 8 areas of the metropolitan region.

Sample

In the present study, the stratified random sampling method with proportional allocation was used to select a statistically representative sample of the population. Cochran's formula was used to calculate the required sample size. Attempts were made to include at least 20 households of each class in the sample so statistical parametric methods could be used to statistically compare the classes. The final sample size increased from 384 households to 395 households, which were proportionally allocated according to the number of households in each of the 8 informal settlements.

Instrumentation

Two questionnaires were designed by the researcher to assess the SDHs determined in the qualitative stage and the health

status of households in informal settlements in the research area. A questionnaire on SDHs was designed due to a lack of appropriate tools for investigating SDHs. To examine the health status of households, given that existing questionnaires mostly focus on individual health, a special questionnaire was designed to assess health status at the family level.

Validity and reliability evaluation of the questionnaires

Face validity was evaluated for the questionnaire items (indicators of SDHs and household health) based on the experts' opinions. Content validity was assessed for the items using the content validity ratio (CVR) and content validity index (CVI) based on the method proposed by Lawshe [15], and internal consistency was measured and determined using Cronbach's alpha coefficients.

In the face validity evaluation, the questions designed to assess each SDH were evaluated by 20 experts and specialists in the fields of health and SDHs and modified according to the experts' comments and suggestions. After applying the required corrections and confirming the face validity, in order to determine the content validity, the importance and relevance of the designed items were assessed by experts to be included in the research questionnaires accordingly.

The questions designed for use in both the SDH and health status questionnaires with CVI values of greater than 0.79 and CVR values of greater than 0.42 were considered to be eligible in terms of content validity that could be used to measure the selected determinants. The final questionnaire used in this survey for assessing SDHs at the population level contained 89 items, which were answered using a Likert scale. The health status questionnaire contained 3 close-ended questions and 2 open-ended questions and was completed by the head of the household on a self-reported basis.

Cronbach's alpha coefficients were used to calculate and measure the internal consistency of the questionnaires. In order to evaluate the reliability of the different dimensions and structures of the questionnaires, a pretest was performed with a sample of 28 households from the statistical population. The Cronbach's alpha value was 0.94 for the SDH questionnaire and 0.88 for the health questionnaire. In addition, the value of this coefficient was higher than 0.70 for all dimensions, indicating that the questionnaires had high reliability, desirability for measuring the research variables, and applicability for receiving answers to the research questions.

Measurement scale

All research questions were answered using a 5-point Likert scale, with 1 indicating “very bad,” “very little,” or “never” and 5 indicating “very good,” “very high,” or “always.” The results were analyzed accordingly.

Data collection

The questionnaires were completed in person and were also designed to be completed digitally. The relevant link was provided to the respondents via a mobile device or email. After an explanation of the aims and significance of the study and the condition of confidentiality regarding the respondents’ data at the beginning of the electronic questionnaires, the questionnaires were completed by the respondents, and their opinions were collected. Since the research questions had to be answered by parents, explanations were provided in the questionnaires that, in instances when the respondents were illiterate or faced other obstacles preventing them from completing the questionnaires independently, a family member could read the research questions aloud to a parent to complete the questionnaires.

Statistical Analysis

In this study, after the data were collected, reviewed, and entered into an Excel spreadsheet to form a database in SPSS version 23.0 (IBM Corp., Armonk, NY, USA), descriptive statistical methods were used to interpret the collected data and observations to determine frequency distribution tables, descriptive diagrams, central tendencies, and dispersion indices such as means, standard deviations, and medians.

In the statistical inferences section, after examining the research variables among the population level according to type, including 89 items related to 43 SDHs and 5 items related to health status, feature selection with multilayer perceptron (MLP) analysis using an artificial neural network (ANN) was used to identify the determinants that had a greater influence on the health status of informal settlement residents in the study area. Due to the need to examine different variables for a very large dataset to study and measure SDHs in any society, using this method was thought to be advantageous.

The use of neural networks to model non-linearity is a computational intelligence technique that has attracted attention in recent research and has been widely used in technical and scientific fields to create models to solve various problems, the results of which have been promising. Researchers in various

fields have recently shown an active interest in using ANNs to solve problems such as bioinformatics data classification and medical diagnosis and prediction [16-20]. ANNs have promising benefits such as non-linearity, noise insensitivity, high parallelism, learning, adaptability, and generalizability.

In simple terms, an ANN consists of processing elements called neurons that are interconnected and work together to respond to a particular problem. ANNs generally have 3 types of layers: input, hidden, and output [21].

One of the most widely used types of ANNs for classification problems is MLP. Feature selection can be used to select the most appropriate and relevant data subset of the main feature and has several applications, even though its main purpose is to increase the accuracy of classification. Feature selection also removes irrelevant or additional noise and features that are not important to the classification task [22].

Ethics Statement

In this study, all research methods were performed in accordance with the relevant guidelines and regulations. Ethical approval was obtained from the Ethics Committee of the University of Social Welfare and Rehabilitation Sciences (ethical code: IR.USWR.REC.1398.165). According to the ethics committee’s instructions, informed consent was obtained from all participants in the various stages of research, and in the case of minors/children, informed consent was obtained from parents or legal guardians.

RESULTS

Qualitative Research Stage

After conducting the second stage of the study using the Delphi method and obtaining the opinions of experts, 43 out of the original 96 SDHs were chosen to be examined at the population level since they had *p*-values of less than 0.05 (Table 1).

Quantitative Research Stage

Demographic characteristics of the selected sample

The demographic characteristics of 395 participants, who were chosen among residents of 8 informal settlements in the studied metropolitan area, were surveyed. According to the results, the selected sample had an average age of about 35 ± 9 years. The predominant age group was 30 years to 40 years, accounting for 44.0% of the sample (173 people). Respondents

Table 1. Social determinants of health to be investigated at the population level

Variables	p-value
D01. Physical structure of housing, lack of strength, durability, and safety of buildings due to the use of brittle, nondurable, and flammable materials	0.026
D02. House seizure (rent, private property, etc.)	0.005
D03. Humidity of houses and low quality of interior space	0.024
D04. Indoor air pollution and poor ventilation	<0.001
D05. Unhygienic toilets	<0.001
D06. Family size, overcrowded and dense family space	0.028
D07. Location of housing (in good or medium or low areas)	0.002
D08. Lack of access to safe, high-quality, and hygienic drinking water	<0.001
D09. Improper disposal of waste, environmental pollution with waste, and waste-transfer stations	<0.001
D10. Inappropriate and open sewer systems	<0.001
D11. Notoriety of the neighborhood	0.036
D12. Environmental pollution of the place of residence, lack of cleanliness, and poor sanitation of neighborhoods	<0.001
D13. Lack of private-sector health facilities	0.015
D14. Lack of access to police services	0.045
D15. Lack of access to public resources (parks, green space, museums, libraries, spaces for sports)	0.033
D16. Insecure public space due to gang crime and conflicts, neighbors' crime and conflicts	<0.001
D17. Whether the mother and father are employed or unemployed	<0.001
D18. Lack of health insurance	0.001
D19. Lack of pension insurance	0.025
D20. Family wealth status	<0.001
D21. Violence, gender discrimination, and unfair behaviors against children in the family	<0.001
D22. Family income, poverty in the family, income insecurity, financial pressure, dissatisfaction with the family's financial situation	0.001
D23. Parental education level, lack of formal education	0.032
D24. Undesirable childhood experiences	0.021
D25. Workplace conditions	<0.001
D26. Having fights, misunderstandings, and conflicts in the family	0.001
D27. Family food insecurity	<0.001
D28. Malnutrition, inadequate and poor diet, and micronutrient deficiencies	<0.001
D29. Food contamination	<0.001
D30. Nutritional habits (such as regular consumption of fast food, the number of times one eats vegetables, fruits, and meat)	<0.001
D31. Inadequate and insufficient public health facilities located at long distances	0.001
D32. Low individual health literacy	<0.001
D33. Insufficient physical activity	<0.001
D34. Not performing health screening and annual tests	<0.001
D35. Stress	<0.001
D36. Not taking care of personal hygiene such as bathing, nail trimming, and tooth-brushing	<0.001
D37. Excessive smoking	<0.001
D38. Addiction of a family member to drugs or alcohol	<0.001
D39. Social support, the number and presence of friends and relatives in the neighborhood, and having a large family	0.041
D40. Social rejection or deprivation and family isolation	0.024
D41. Low participation in religious ceremonies	0.012
D42. Job satisfaction	0.004
D43. Job insecurity	<0.001

under 20 years of age accounted for only 0.5% of the total sample. In addition, 21.8% (86 people) and 21.5% (86 people)

of the respondents were 20-29 years old and 40-49 years old, respectively.

Table 2. Descriptive statistics of research variables at the population level in informal settlements

Variables	Mean ± SD	Variables	Mean ± SD	Variables	Mean ± SD
D06	2.08 ± 0.81	D20	2.77 ± 1.35	D30	3.34 ± 0.61
D15	2.24 ± 0.96	D01	2.78 ± 0.75	D08	3.41 ± 1.00
D22	2.35 ± 0.87	D12	2.81 ± 0.99	D32	3.50 ± 0.67
D34	2.41 ± 1.08	D25	2.81 ± 0.90	D41	3.53 ± 1.10
D14	2.46 ± 1.04	D28	2.88 ± 0.82	D18	3.89 ± 1.80
D13	2.53 ± 0.90	D11	2.92 ± 0.84	D26	3.98 ± 1.01
D19	2.53 ± 1.95	D39	2.92 ± 0.85	D05	4.02 ± 1.26
D23	2.59 ± 0.81	D24	2.97 ± 0.79	D29	4.02 ± 0.68
D17	2.60 ± 1.07	D02	2.99 ± 1.20	D21	4.07 ± 0.88
D07	2.64 ± 1.48	D43	3.01 ± 1.40	D27	4.07 ± 0.93
D31	2.65 ± 0.75	D09	3.05 ± 0.96	D37	4.24 ± 1.12
D33	2.66 ± 1.02	D42	3.08 ± 1.00	D36	4.30 ± 0.85
D35	2.66 ± 1.14	D10	3.21 ± 1.48	D38	4.63 ± 1.17
D40	2.68 ± 1.05	D03	3.28 ± 0.91	Health	3.85 ± 0.62
D16	2.73 ± 0.97	D04	3.30 ± 1.06		

SD, standard deviation.

A total of 88.4% of the respondents belonged to families where 2 parents lived together, and 11.6% of the families were single parents due to divorce or the death of a parent. In addition, 55.9% of the respondents were fathers in the household, 32.4% were mothers in the household, and 11.7% were children in the household.

Frequency distributions of the respondents' opinions for the 43 SDHs (independent variables) and the health status of informal settlement residents (dependent variables), which were measured based on an interval scale ranging from 1 to 5, are shown in Table 2. According to the results, SDHs with mean values of close to 5 were more favorable to informal settlement residents (Table 2).

Table 2 shows the descriptive statistics results. Comparative analysis of the estimated means showed that, of the 43 SDHs, the highest level of dissatisfaction was related to D06 (family size, overcrowded and dense family space) and D15 (lack of access to public resources such as parks, libraries, and sports facilities), with mean values of 2.08 and 2.24, respectively.

Regarding the dependent variable (family health status), according to the participants' opinions on this variable (mean, 3.85), it could be concluded that they assessed their family's health status as slightly better than the average, and the low dispersion of opinions (standard deviation, 0.62) showed that most of the participants shared similar opinions about their families' health.

Table 3. Case processing summary

Case	n (%)
Sample	
Training	269 (68.1)
Testing	126 (31.9)
Valid	395 (100)
Excluded	0 (0.0)
Total	395 (100)

Statistical analysis and inference about the research variables

After examining multiple networks with different hidden layers, multiple learning functions, and different training algorithms in SPSS software, an MLP using an ANN with an error back-propagation algorithm was used to analyze the data. This network included 43 input layers (variables), 19 hidden layers, and 1 output layer (health).

The necessary commands were executed in SPSS and the ANN section. A summary of the required statistical data in the training and testing portions of the MLP analysis is shown in Table 3. According to the results, it was found that, for the ANN-based MLP analysis, data on approximately 68% of the selected sample were used to train the ANN model, and data on the remaining 32% were used to test and validate the results. Data selection for testing and training was also performed randomly (Table 3).

Two important statistics used in the fitness stages and different layers of ANN models are the sum of squares error and

Table 4. Model Summary

Stages		Result
Training	Sum of squares error	0.584
	Relative error	0.004
	Stopping rule used	1 consecutive step(s) with no decrease in error
	Training time	0:00:00.83
Testing	Sum of squares error	0.607
	Relative error	0.011

relative error, and their convergence and comparison in the 2 parts of training and testing were important. As shown in Table 4, the approximate equality of these 2 statistics in 2 stages indicates the consistency of the results and validity of the applied ANN model.

After performing the necessary analyses and applying the feature selection method in ANN, it was determined which SDHs had a greater degree of influence among those in the sample and could be representative of other SDHs. Using this method, 43 SDHs were ranked based on their degree of influence on the health status of households from informal settlements.

Based on the normalized importance of SDHs in implementing the feature selection method using MLP in ANN, the most important determinants were prioritized as substitutes for other health determinants, the results of which are shown in Table 5. Accordingly, 15 variables with a normalized importance of more than 80% were determined and selected.

Therefore, the first 15 variables in Table 5 were considered to have nearly 80% of the features of all variables and were selected as representative of high-priority SDHs that could be used in health promotion interventions.

DISCUSSION

Informal settlement residents are at higher risk of developing physical and mental diseases than the general population. According to the Commission for Social Determinants of Health, health status and well-being are significantly affected by the living environment [23]. Given the extent and diversity of SDHs as well as the high cost and time commitment required to address all of them in interventions, the main purpose of this study was to determine, based on the opinions of informal settlement residents in the study area, which SDHs played the greatest role in improving and promoting the residents' health in

order to address them in interventions to improve the physical and mental health of informal settlement residents.

After conducting the analysis, 15 representative SDHs were selected as the high-priority SDHs for use in health promotion interventions. While the other SDHs are also important and should not be ignored, these 15 determinants are disproportionately influential and explain almost 80% of the features of all the variables. Health promotion interventions in informal settlements in the study area that focus on these variables would have a greater effect on improving the health of the residents.

Studies on SDHs in informal settlements have examined many determinants. Nekoei-Moghadam et al. [24] conducted a study in a city in Iran to identify the health problems of those living in informal settlements based on SDHs using a completely different method from that of the present study; however, their investigation had multiple similarities to the current study. In the previous study, factors such as job status, unfavorable childhood experiences, nutrition, and social support were reported as the main dimensions, and other factors such as dense family space were reported as SDHs that showed high importance in promoting the health of settlement residents. Nonetheless, in their research, factors such as a lack of access to public resources, health literacy, and non-compliance with personal hygiene were not included, indicating that the present study was more comprehensive and provided a more in-depth framework of health determinants.

Lumagbas et al. [25], in a study on non-communicable diseases in Indian slums, concluded that the 4 most important causes of non-communicable diseases were a lack of clean water, the transportation system, inadequate physical activity, and poor education. These factors were identified as lower-priority in this study, indicating that the important health determinants may differ by region. Thus, interventions to improve the health of inhabitants of a specific city or region should be based on evidence from the same region.

Of the 15 determinants identified in this study, 4 were related to housing and housing quality, indicating that interventions for various issues related to housing, such as building safety, quality of materials used in the building, the interior quality of housing, and other items, are very important for improving the health of residents in these areas and therefore should be considered in health-promotion intervention programs. Weimann and Oni [26] pointed out that housing structure was associated with certain health consequences, and

Table 5. Results of neural networks in ranking social determinants of health

Variables	Variable name	Importance	Normalized importance (%)
D32	Low individual health literacy	0.034	100
D04	Indoor air pollution and poor ventilation	0.032	93.0
D28	Malnutrition, inadequate and poor diet, and micronutrient deficiencies	0.031	91.3
D13	Lack of private-sector health facilities	0.030	87.6
D43	Job insecurity	0.029	85.9
D06	Family size, overcrowded and dense family space	0.029	85.1
D01	Physical structure of housing, lack of strength, durability, and safety of buildings due to the use of brittle, nondurable, and flammable materials	0.029	84.8
D39	Social support, the number and presence of friends and relatives in the neighborhood, and having a large family	0.029	84.2
D25	Workplace conditions	0.029	84.1
D03	Humidity of houses and low quality of interior space	0.028	83.3
D24	Undesirable childhood experiences	0.028	83.2
D36	Not taking care of personal hygiene such as bathing, nail trimming, and tooth-brushing	0.028	81.2
D15	Lack of access to public resources (parks, green space, museums, libraries, spaces for sports)	0.028	81.0
D16	Insecure public space due to gang crime and conflicts, neighbors' crime and conflicts	0.027	80.4
D17	Whether the mother and father are employed or unemployed	0.027	80.0
D30	Nutritional habits (such as regular consumption of fast food, the number of times one eats vegetables, fruits, and meat)	0.027	78.1
D08	Lack of access to safe, high-quality, and hygienic drinking water	0.026	76.0
D22	Family income, poverty in the family, income insecurity, financial pressure, dissatisfaction with the family's financial situation	0.026	75.1
D09	Improper disposal of waste, environmental pollution with waste, and waste-transfer stations	0.025	74.0
D12	Environmental pollution of the place of residence, lack of cleanliness, and poor sanitation of neighborhoods	0.025	72.6
D29	Food contamination	0.024	71.1
D41	Low participation in religious ceremonies	0.024	70.7
D23	Parental education level, lack of formal education	0.024	69.7
D40	Social rejection or deprivation and family isolation	0.024	69.4
D37	Excessive smoking	0.023	68.2
D31	Inadequate and insufficient public health facilities located at long distances	0.023	67.6
D35	Stress	0.023	66.4
D11	Notoriety of the neighborhood	0.022	65.5
D27	Family food insecurity	0.022	64.7
D34	Not performing health screening and annual tests	0.021	61.9
D33	Insufficient physical activity	0.021	61.8
D14	Lack of access to police services	0.021	60.5
D21	Violence, gender discrimination, and unfair behaviors against children in the family	0.020	59.5
D42	Job satisfaction	0.020	58.6
D20	Family wealth status	0.019	55.0
D26	Having fights, misunderstandings, and conflicts in the family	0.019	54.8
D10	Inappropriate and open sewer systems	0.019	54.3
D05	Unhygienic toilets	0.017	50.9
D02	House seizure (rent, private property, etc.)	0.015	44.4
D07	Location of housing (in good or medium or low areas)	0.011	32.5
D38	Addiction of a family member to drugs or alcohol	0.009	25.0
D19	Lack of pension insurance	0.007	19.6
D18	Lack of health insurance	0.006	17.5

improving housing affected the health of residents over time. Silva et al. [27] found that 3 studies confirmed the relationship between poor housing and worse mental health in their literature review.

Three of the high-priority social determinants identified in this study were related to occupational factors, indicating the influence of occupational factors and related variables on the health of informal settlement residents. The link between employment/unemployment and diseases such as acquired immunodeficiency syndrome has been confirmed in various studies [28,29]. In a study by Gruebner et al. [30], job and job satisfaction were reported as factors that affect the mental health of slum dwellers. Pawar et al. [11] showed that social isolation and a lack of social support were significantly associated with illness. Another study also showed that social support for residents of informal settlements was an important social determinant of hypertension and diabetes [31].

Nutrition, hygienic behaviors, and childhood experiences are also important categories that affect the health of settlement residents. Agarwal and Srivastava [32] found that improving the nutritional and developmental status of children was particularly important due to their positive impact on children's health. The results of a study by Mondal et al. [33] on behavioral determinants of non-communicable diseases in informal settlements in Bangladesh showed that behavioral factors such as tobacco and alcohol consumption, as well as insufficient consumption of fruits and vegetables, affected the prevalence of non-communicable diseases. A lack of access to public resources; a lack of facilities such as laboratories, pharmacies, and doctors' offices; and insufficient public spaces were also identified in the present study as influential SDHs that should be prioritized in health promotion interventions. In order to increase settlement residents' ability to utilize to private-sector and public-sector clinics and laboratories and their use of these services at an affordable cost, the government should provide access to these facilities and take special measures to improve access, such as by implementing tax reduction programs.

Studies have shown that unfavorable socioeconomic circumstances and inadequate urban services directly impact the health of informal settlement residents in metropolitan areas, and improving neighborhoods to create a healthier environment in settlements is likely to be economically viable and increase the return on investment [34,35]. Therefore, reviewing the literature demonstrates that the findings of the pres-

ent study have also been identified in previous research and can be used in health promotion programs in the metropolitan area in this study. In addition, the results of descriptive statistics (Table 2), which quantified the status of each SDH in informal settlements, were arranged by mean value, with SDHs with lower mean values indicating lower favorability among residents of informal settlements. A comparison of these results with the ANN results regarding which SDHs to prioritize (Table 5) reveals that only 5 variables in Table 2 that were unfavorable among those in the study population were selected as high-priority SDHs to be included in community interventions, indicating that decisionmakers should not consider the unfavorability scores of variables when planning interventions since these variables may not greatly affect the health of residents. Instead, to have the greatest impact on the health of settlement residents, interventions should focus on the high-priority variables included in Table 5.

Since the study of SDHs could improve justice in health care and health services and compensate for the disproportionately poor health status of slum residents, multiple previous studies have examined the SDHs of settlement residents in order to improve their conditions. Despite the extensive research in this field, due to the extent and diversity of SDHs, few studies have examined SDHs among informal settlement residents at the total population level, and sufficient evidence has not yet been found to implement measures and interventions based on the findings of previous studies. Therefore, similar studies should be conducted in different cities and countries, especially in developing countries, and the results should be used by policymakers to improve the health of settlement residents.

This study is significant since it is one of the first studies to introduce a solution for examining the impact of SDHs at the population level. This study also implemented a new method using an ANN to identify the highest-priority determinants and creatively design an evidence-based intervention program. The present research also provided a framework for examining SDHs and analyzed a wide range of SDHs at the population level, while other studies have examined smaller selections of SDHs. The opinions of residents of these areas were collected using reliable statistical and field research data collection methods; therefore, the results are more reliable than those of other related studies and can be used by planners and city managers, creating a basis for implementing evidence-based interventions for informal settlement residents. A limitation of this study is that, due to social and structural differences by region,

the research results should not be generalized to all cities or settlements, and further region-specific studies must be conducted.

The importance of SDHs in health promotion is clear, and the health status of informal settlement residents is worse than residents of other areas due to unfavorable socioeconomic circumstances. Therefore, given the breadth of SDHs, managers, policymakers, and urban planners in any city or region should consider using the ANN method from this study to identify high-priority SDHs and, according to the area's available budget, implement interventions and measures to promote the health of inhabitants. In order to use SDHs to improve the health of informal settlement residents, in addition to examining previous literature, the opinions of experts and residents should also be considered. In addition, intervention programs to improve the health of settlement residents should be designed with the involvement of policymakers, professionals, and, in particular, residents.

CONFLICT OF INTEREST

The authors have no conflicts of interest associated with the material presented in this paper.

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AUTHOR CONTRIBUTIONS

Conceptualization: Ghamari MR. Nejad FN. Data curation: Nejad FN. Kamal SHM. Tabatabaee SS. Formal analysis: Ghamari MR. Funding acquisition: None. Methodology: Kamal SHM. Ghamari MR. Project administration: Tabatabaee SS. Ghamari MR. Writing – original draft: Ghamari MR, Tabatabaee SS. Writing – review & editing: Nejad FN. Kamal SHM. Ghamari MR.

ORCID

Farhad Nosrati Nejad <https://orcid.org/0000-0001-7024-3022>

Mohammad Reza Ghamari

<https://orcid.org/0000-0003-1189-5447>

Seyed Hossein Mohaqeqi Kamal

<https://orcid.org/0000-0003-2550-7898>

Seyed Saeed Tabatabaee

<https://orcid.org/0000-0001-5758-0681>

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