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Journal of Research in Health Sciences

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## Original Article

# Comparison of Small Area Techniques for Estimating Prevalence of Mental Disorder Symptoms among Iranian's Southern Adolescents

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## ARTICLE INFORMATION

### Article history:

Received: 11 September 2013

Revised: 19 December 2013

Accepted: 28 December 2013

Available online: 15 January 2014

### Keywords:

Mental health

Small area technique

Prevalence

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## ABSTRACT

**Background:** Mental disorders may lead to several complications in adolescents' people whose compensation is very difficult and sometime impossible. They are prone to emotional problems. Therefore, knowing prevalence of diseases and valid statistical technique is necessary to plan for prevention and control of diseases.

**Methods:** In this cross-sectional study; direct, synthetic, and post-stratified estimation as small area methods were used to compute mental disorder symptoms (MDS) prevalence with county-level reference among adolescents in south of Iran. We conducted Mental Health Study data (MHS) conducted in Bushehr Province, southern Iran in 2005 for individual-level classification of MDS (n=2584). Students were in grade 9, 10 and 11, and enrolled with complete satisfaction.

**Results:** The synthetic method was superior to the direct and post-stratified technique with respect to discrepancy statistics such as MSE and width 95% confidence interval ( $MSE_{(synthetic)} \approx 0.001$ ,  $MSE_{(post-stratified)} \approx 0.010$ ,  $MSE_{(direct)} \approx 0.100$ ). In addition, the width range of 95% confidence intervals for all county estimates was 9.7% to 65.3% based on in direct methods. Besides, the width range of 95% confidence intervals for all county estimates under post-stratified and synthetic method was 16.7% to 62.2% and 11.8 %-25.1%, respectively. Hence, we could categorize prevalence of mental disorder symptoms in Bushehr's counties into five categories based-on synthetic methods. Maximum and minimum prevalence belongs to Geneveh (0.403) and Dashty (0.398) counties, respectively.

**Conclusions:** The MHS cannot be used as a valid source of county-level mental health prevalence data and the small-area method such synthetic method should be used to estimate prevalence of mental disorder symptoms in county-level. Furthermore, the synthetic method improved MDS prevalence more than direct and post-stratified methods.

**Citation:** Tohidnejad E, Soltanian AR, Roshanaei G. Comparison of Small Area Techniques for Estimating Prevalence of Mental Disorder Symptoms among Iranian's Southern Adolescents. J Res Health Sci. 2014; 14(2): 146-151.

## Introduction

General health and psychiatry status is one of assessment of indicators in human societies<sup>1,2</sup>. Mental disorder symptoms may lead to several complications in people whose compensation is very difficult and sometime impossible. Adolescence is a most critical period of life, and they are prone to emotional problems. Based on results of the national burden of disease in six provinces of Iran including East Azerbaijan, Bushehr, Chaharmahal-Bakhtiari, Khorasan (larg), Hormozgan and Yazd, psychiatric disorder is ranked second in terms of disease burden<sup>3</sup>. Moreover, major depression is ranked fourth in terms of disease burden (DALY=2744 per 100000) among aged 15-44 years<sup>3</sup>. The previous study showed that prevalence of mental disorder was high and approximately a fifth of the people 15 years and over had mental disorders in Iran<sup>4</sup>. In addition, some studies have demonstrated that harm climate can affect direct or indirect on mental health and behavior<sup>3</sup>.

Therefore, knowing prevalence of diseases is necessary for planning the prevention and control of diseases among

adolescents. The previous study shows a large population of Bushehr's adolescents had mental disorders symptoms<sup>5</sup>. But still pattern, variation, and prevalence of mental disorder symptoms among adolescents in Bushehr province's counties are unclear. Reviews of previous studies show that mental disorder among adolescents is very important<sup>4,5-7</sup>. But there is not always possibility to investigate in any counties. In other words, sample size to estimate prevalence of mental disorder symptoms was not sufficient or proper in Bushehr's counties. Usually, in epidemiological studies sample size was estimated for a large area (e.g., province), then the sample size was divided between smaller areas (e.g., counties, cities, etc.) using quota or proportional share. In this way, we cannot find prevalence in each county, because the sample size was calculated based on province information. Here communities are called small area and cannot be obtained sufficient accuracy estimator using direct methods. In this way small area method, indirect method should be used to estimate the prevalence of events.

The first aim of this study was to determine the prevalence of mental disorder symptoms using small area methods (e.g. direct, synthetic and post-stratified approaches) among high school students in eight Bushehr’s counties. The second aim was comparison precision of the methods for estimation of mental disorder symptoms in Bushehr’s counties under mean of square error (MSE). Therefore, results of the study can be used to Iranian’s policy makers for programming and prevent further prevalence of mental disorders.

**Methods**

We used direct, synthetic, and post-stratified estimation to compute lack of general health prevalence with county-level reference <sup>8</sup> among adolescents in south of Iran for small-area analysis. In addition, we examined accuracy of both methods for small-area analysis using mean of square error, MSE <sup>9-11</sup>.

**Data Source**

The 2005 MHS data (Mental Health Study) <sup>2, 5</sup>, a cross-sectional study was used for individual-level classification of mental disorder symptoms. The MHS was conducted on 2584 students aged 15-19 years. The number of students was determined by proportion sampling method by sex and grade level in counties. In the study main outcome was mental disorder symptom. The Iranian version of the GHQ-28 <sup>12</sup> was used to estimate mental health status that is a screening instrument for psychiatric disorders <sup>13, 14</sup>. The MHS included questions such as socio-economic, physical activity, food consumption pattern, and demographic variables. County-specific data, number of student by sex and grade as auxiliary variables, were collected from Bushehr Educational and Training Institution. If students had mental illness or had an exam during previous month were excluded. Students who had satisfaction to participate in study and were in grade 9, 10 and 11 were enrolled. Multi-stage sampling technique was used in the MHS, where number of students was determined by proportion approach based on sex ration in counties, schools, and student’s grade. First, 50% of schools in each county were selected randomly by sex ration. Second, we selected one of grade in each school randomly. Third, proportionally selected students were based on class notebook.

Mental disorder symptoms was measured using the 28-item General Health Questionnaire (GHQ-28) that is a screening instrument for psychiatric disorders. The Iranian version of the GHQ-28 was also used to estimate mental health state. Frequency of student by sex and grades as two auxiliary variables were given from Bushehr Educational

and Training Institution office. Mental disorder symptom was taken from MHS in 2005. Validity and reliability of GHQ-28 was acceptable <sup>2,5</sup>. The 28-items GHQ is scored on a four point Likert-type scale according to a 0-1-2-3 system <sup>2</sup>. Questions in GHQ-28 item were supplemented by students themselves. The MHS was conducted one month prior to the students’ examinations or any quizzes, and student in the 12th grade were excluded because of their final quizzes and examinations.

**Data Analysis**

The software R version 2.12.0 was used for data analysis. Mean of square error (MSE) was calculated using Jackknife methods to adjust for complex and compare small area approaches together (e.g. synthetic, direct and post-stratified methods) <sup>8,9</sup>. County-level prevalence of mental disorder symptoms was estimated by applying the same data to each small area analysis method under study. Geometry information of county as shape file interned to Arc-Map (version 9.3) software and the maps were showed by the software. Statistical significant level was considered less than 0.05.

**Estimation Methods**

*Direct estimation:*

Direct prevalence estimates for mental disorder symptoms were obtained with following equation for counties <sup>8</sup>,

$$\hat{P}_i^{direct} = \frac{\hat{Y}_i}{\hat{N}_i}$$

Where,  $\hat{P}_i$  is the estimated prevalence of mental disorder symptoms in county  $i^{th}$  ( $i = 1, 2, \dots, 8$ ) under direct method,  $\hat{Y}_i$  is the number of participants in county  $i^{th}$  with mental disorder symptoms, and  $\hat{N}_i$  is the sample size in county  $i^{th}$ .

*Synthetic estimation:*

Synthetic estimation uses auxiliary data <sup>8</sup>. Distribution of participants by sex and schools’ grade were used as auxiliary variables, correlated with the general health status. To obtain synthetic estimation the population was first divided into sub-groups according to the auxiliary variables. Second, small area estimations were calculated for each sub-group in counties. The sum of these sub-group estimates across all categories of the auxiliary variable produces the synthetic estimates for the sub-area. Table 1 illustrates the calculation procedure of synthetic estimation of MDS prevalence denoted by “p”. Here counties of Bushehr Province are the “small areas”. Table 1 divides the auxiliary variables, school grade and sex, into three and two sub-groups.

**Table 1:** Synthetic estimation with two auxiliary variables for region or county  $i^{th}$

School grade (Auxiliary variable II)	Gender (Auxiliary variable I)					
	Sub-group I (Males)		Sub-group II (Females)		Total	
	Count	prevalence	Count	Prevalence	Count	Prevalence
Sub-group (I) or grade 9	$N_{11}$	$P_{11}$	$N_{12}$	$P_{12}$	$N_{0,1}$	$P_{0,1}$
Sub-group (II) or grade 10	$N_{21}$	$P_{21}$	$N_{22}$	$P_{22}$	$N_{0,2}$	$P_{0,2}$
Sub-group (III) or grade 11	$N_{31}$	$P_{31}$	$N_{32}$	$P_{32}$	$N_{0,3}$	$P_{0,3}$
Total	$N_{0,1}$	$P_{0,1}$	$N_{0,2}$	$P_{0,2}$	$N_i$	$P_i$

Therefore, the synthetic estimation of small area with two auxiliary variables denoted <sup>8</sup>,

$$\hat{P}_i = \sum_g \frac{N_{ig}}{\sum_g N_{i,g}} \hat{P}_{g}$$

where  $\hat{P}_i$  is the estimated prevalence of mental disorder symptoms in county  $i$  ( $i = 1, 2, \dots, 8$ ) under synthetic method,  $N_{ig}$  is the number of people in county  $i$  that belong to  $g^{th}$  level of auxiliary variables  $g = 1, 2, \dots, 6$ ), and  $\hat{P}_g$  is the estimated state level sex-school grade prevalence rates.

Post-stratified estimation:

Post-stratified prevalence estimates for mental disorder symptoms were obtained with following equation for counties <sup>8</sup>,

$$\hat{P}_i^{Post} = \frac{\sum_g N_{ig} \hat{P}_{ig}}{\sum_g N_{ig}}$$

where,  $\hat{P}_i$  is the estimated prevalence of mental disorder symptoms in county  $i^{th}$  ( $i = 1, 2, \dots, 8$ ) under post-stratified method,  $N_{ig}$  is the sample size in county  $i^{th}$  and stratify  $g^{th}$  ( $g = 1, 2, \dots, 6$ ; complex of sex (male and female) and students' grade (grades 9, 10 and 11)), and  $\hat{P}_{ig}$  is the estimated prevalence mental disorder symptoms in county  $i^{th}$  and stratify  $g^{th}$ .

Results

Relation between outcome and auxiliary variables

In 2005, the MHS sampled a total 2584 high-school students aged 15 to 19 years. The overall self-reported prevalence of mental disorder symptoms was 40.7% [95%CI: 38.8%, 42.59%]. There was a significant association between mental disorder symptoms and students' sex and grade. Girls were approximately 22% more self-reported mental disorder symptoms than boys (OR= 1.217, [95%CI: 1.034, 1.434];  $P=0.018$ ). Distribution of participants by county, sex and schools' grade is showed in Table 2.

Table 3 shows that mental disorder symptoms in counties under direct method and two small-area methods, synthetic and post-stratified. First, prevalence of mental disorder symptoms under three methods was estimated. Second, to validate direct method and each small-area method together, MSE was calculated by Jackknife approach (Table 3). In addition, the map of direct, synthetic and post-stratified estimates was scattered for county clustering.

Jackknifes' MSE for verify Validity Estimators

The Jackknife MSEs show that the synthetic method improved MSE county-level estimates greatly over direct and post-stratified estimation (Table 3). Moreover, we can say that post-stratified method improved MSE county-level of mental disorder symptoms prevalence over than direct method (Table 3, small values of MSE are better). Maximum prevalence of mental disorder symptoms under direct, synthetic and post-stratified methods belongs to Dayyer, Deylam, and Dayyer, respectively. Besides, minimum prevalence of mental disorder symptoms under direct, synthetic and post-stratified methods belongs to Tangestan, Dashtestan, and Tangestan, respectively.

Jackknifes' Confidence Interval 95% for Estimators

For second time, to evaluate county-level estimates we calculated the width of 95% confidence intervals for all county estimates under three methods. In direct methods, the width range of 95% confidence intervals for all county estimates was 13%-53.6%. Furthermore, the width range of 95% confidence intervals for all county estimates under post-stratified and synthetic method was 16.7%-62.2% and 11.8 %-25.1%, respectively.

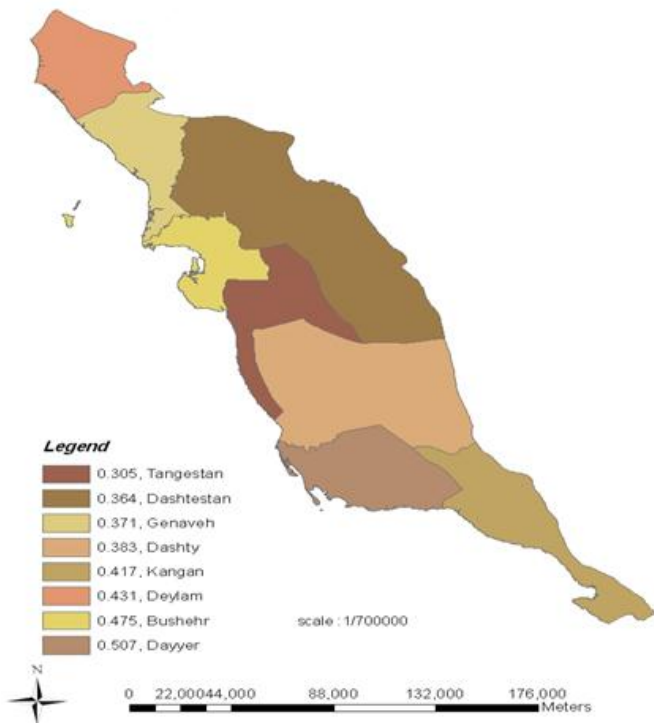
Maps of Mental Disorder Symptoms Prevalence

The map of mental disorder symptoms prevalence in Bushehr's counties with direct method showed that they were no clustered into categories (Figure 1). Under Figure 1 we cannot observe any pattern for prevalence of mental disorder symptoms in Bushehr's counties.

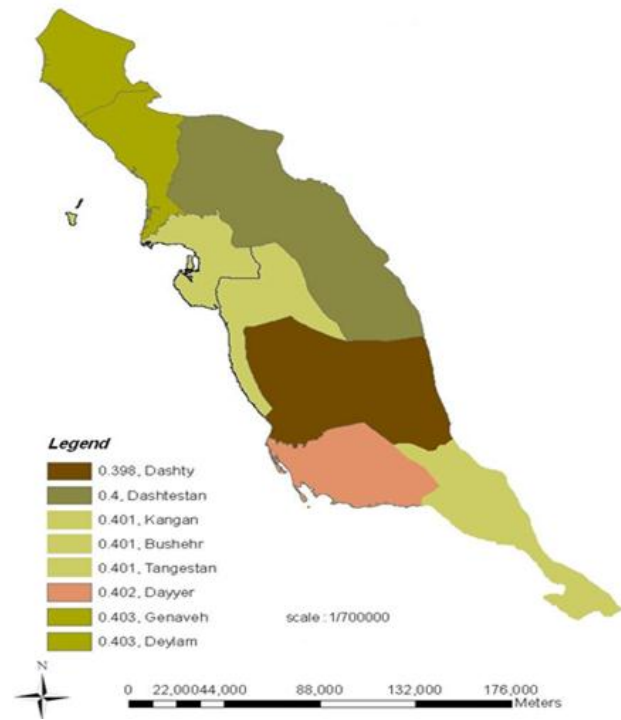
Table 2: Frequency and prevalence of mental disorder symptoms based on GHQ-28 among adolescents in Boushehr Province in 2005

County	Grade	Sample size	Prevalence (%)
<b>Bushehr</b>			
Female	9	96	43
	10	134	75
	11	109	68
Male	9	100	41
	10	133	60
	11	114	39
<b>Dayyer</b>			
Female	9	22	11
	10	22	10
	11	22	17
Male	9	22	11
	10	23	8
	11	25	12
<b>Deylam</b>			
Female	9	19	9
	10	19	9
	11	22	10
Male	9	17	4
	10	17	4
	11	22	14
<b>Kangan</b>			
Female	9	41	21
	10	36	15
	11	34	19
Male	9	27	12
	10	45	11
	11	40	15
<b>Dashtestan</b>			
Female	9	95	32
	10	113	46
	11	88	42
Male	9	154	44
	10	128	45
	11	118	44
<b>Tangestan</b>			
Female	9	9	0
	10	29	6
	11	17	2
Male	9	30	15
	10	50	16
	11	29	11
<b>Genaveh</b>			
Female	9	59	13
	10	55	14
	11	62	30
Male	9	60	23
	10	68	27
	11	63	29
<b>Dashty</b>			
Female	9	23	6
	10	23	6
	11	34	11
Male	9	32	13
	10	11	8
	11	78	27

The map of mental disorder symptoms prevalence in Bushehr's counties using synthetic method showed that they were clustered into five categories (e.g. Dashty in first category; Dshtestan in second category; Bushehr, Kangan and Tangestan in third category; Dayyer in fourth category; Dylam and Genaveh in fifth category; Figure 2).



**Figure 1:** Prevalence of lack-of-general health obtained among high-school students using the direct method in Bushehrs’ counties



**Figure 2:** Prevalence of lack-of-general health obtained among high-school students using the synthetic method in Bushehrs’ counties

**Table 3:** Prevalence of mental disorders symptoms using Jackknifes’ method among high-school students by county, in Bushehr Province, 2005

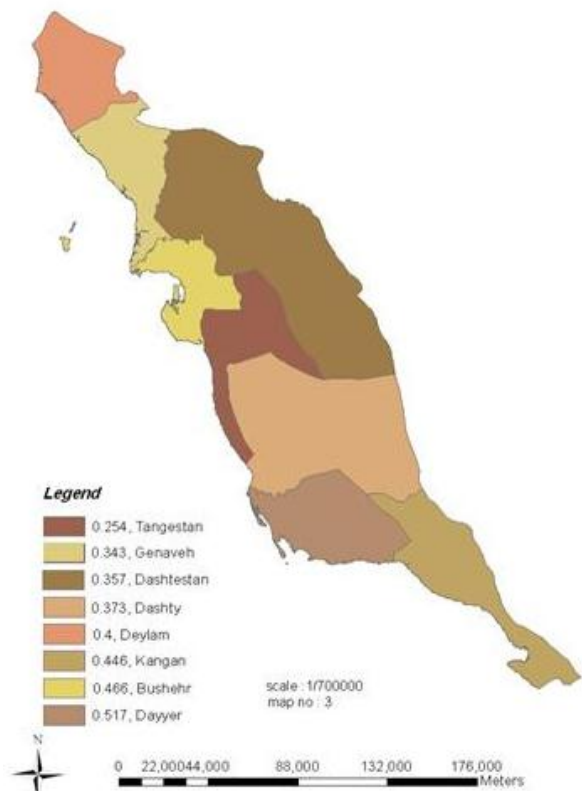
County	Methods (Jackknifes’)					
	Direct		Synthetic		Post-stratified	
	Prevalence (95% CI)	MSE	Prevalence (95% CI)	MSE	Prevalence (95% CI)	MSE
Bushehr	0.475 (0.363, 0.578)	0.0017	0.401 (0.339, 0.458)	0.0005	0.466 (0.3699, 0.556)	0.0013
Deylam	0.431 (0.224, 568)	0.0539	0.403 (0.338, 0.464)	0.0006	0.400 (0.227, 0.566)	0.0044
Dashtestan	0.363 (0.312, 0.442)	0.3107	0.400 (0.339, 0.456)	0.0005	0.357 (0.269, 0.436)	0.0011
Dayyer	0.507 (0.401, 0.646)	0.0291	0.402 (0.339, 0.460)	0.0006	0.517 (0.404, 0.629)	0.0019
Kangan	0.417 (0.402, 0.557)	0.08616	0.401 (0.339, 0.458)	0.0005	0.447 (0.365, 0.535)	0.0011
Tangestan	0.305 (0.047, 0.583)	0.7367	0.401 (0.339, 0.458)	0.0005	0.254 (0.011, 0.569)	0.0147
Genaveh	0.371 (0.125, 0.501)	0.2764	0.403 (0.338, 0.462)	0.0006	0.343 (0.207, 0.470)	0.0026
Dashty	0.383 (0.311, 0.545)	0.3700	0.399 (0.335, 0.456)	0.0004	0.373 (0.238, 0.507)	0.0027

Figure 3 shows that prevalence of mental disorder symptoms in Bushehr’s counties using post-stratified method. In this case, the prevalence’s were clustered into five categories (e.g. Dashty is first category; Dshtestan is second category; Bushehr, Kangan and Tangestan is third category; Dayyer is fourth category; Dylam and Genaveh is fifth category; Figure 3).

### Discussion

We recruited MHS’s data and determined mental disorder symptoms in Bushehrs’ counties for first time among adolescents. In MHS sample size was determined under province-level, but not based on counties-levels. Therefore, we could not determine LGH prevalence in Buserhrs’ counties based on MHS. Hence, we decided to use small-area techniques to estimat LGH prevalence in Bushehrs’ counties. The synthetic method was superior to the direct and post-stratified method with respect to discrepancy statistics such as MSE and width 95% confidence interval.

The results show that direct estimation had the largest discrepancies. This is because the MHS in not designed to produce subpopulation county-level estimates. Although post-stratified appears to be the suitable small-area analysis technique, we observed that synthetic estimation often performed better than post-stratified and other approaches when no county-level variables were significantly associated with the outcome. The synthetic method has been used widely in public health practice<sup>15-17</sup>. However, some of researchers have also used Bayesian methods<sup>18, 19</sup> and other methods such complex regression analysis<sup>10, 20</sup> to produce estimates. At present, we cannot say which method is better than others. Thus, we compared MSEs’ three approaches to prove beneficial. However, based on synthetic approach prevalence of mental disorder symptoms in Bushehr counties as same as overall prevalence in province is high. Mental disorders such depression is more prevalent in tropical regions<sup>6</sup>.



**Figure 3:** Prevalence of mental disorders symptoms based on GHQ-28 among high-school students using the post-stratified method in Bushehr's counties

The synthetic technique shows that less LGH prevalence in Bushehr Province belonged to Dashty county, and also prevalence of mental disorder symptoms in port counties of the sea border (e.g., Genaveh, Deylam, Dayyer, Tangestan, Kangan, and Bushehr; Figure 2) was more than the counties that had not common borders with the sea (e.g., Dashtestan and Dashty). This result may be due to the difference height from the sea between Dashtestan and Dashty counties, and the others counties. The climate of Dashtestan and Dashty is high humidity than the others, because they are faraway Persian Gulf. Medical geography science and previous studies showed climate effect on mental health<sup>6,21</sup>. In addition, some studies have demonstrated that geography and climate can affect directly or indirectly on mental health and behavior changes<sup>22,23</sup>. In the study MSE methods were estimated by Jackknifes' approach that it is an appropriate method for determine variance, bias or mean square error. We have not several auxiliary variables but student frequency by sex and grade in Bushehr Educational and Training Institution was valid. Finally, prevalence of mental disorders symptoms was high in all Bushehrs' areas, particularly in warm and moist area. Thus, perhaps the humid conditions can be cause of mental disorders.

The main limitation of the post-stratified method is that it requires area-level demographic data, which might be not available in counties. Similarly, there is not a survey on adolescents' mental health in Bushehr Province, and also selection auxiliary variables were difficult. In addition MHS was done in 2005 which seems old. To apply small-area approach we need suitable auxiliary variable based on census data or surveys that we do not have access to.

We suggest that school psychologists use to consult the students at risk for early anthropologist. Similarly, student's

psychology status design and register in a database. Finally, because of the lack of supporting data census we suggest that bays' method is used to estimate the mental disorders prevalence.

## Conclusions

In summary, the synthetic small-area estimation procedure is relatively computationally simple and provides an estimation improvement over the direct and post-stratified methods. This study provided evidence that the MHS cannot be used as a valid source of county-level mental health prevalence data and the small-area method such synthetic method should be used to estimate prevalence of mental disorder symptoms in county-level. Moreover, the synthetic method improved LGH prevalence more than direct and post-stratified methods.

## Acknowledgments

This article is a part of MSc thesis supported by Hamadan University of Medical Sciences. We would like to thank Deputy of Education as well as Deputy of Research and Technology of Hamadan University of Medical Sciences for funding this study.

## Conflict of interest statement

The authors have declared that no competing interests exist.

## Funding

Research Center for Health Sciences in Hamadan University of Medical Sciences supported this research.

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