Effectiveness of diabetes and hypertension management by rural primary health-care workers (Behvarz workers) in Iran: a nationally representative observational study

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Summary

Background Non-communicable diseases and their risk factors are leading causes of disease burden in Iran and other middle-income countries. Little evidence exists for whether the primary health-care system can effectively manage non-communicable diseases and risk factors at the population level. Our aim was to examine the effectiveness of the Iranian rural primary health-care system (the Behvarz system) in the management of diabetes and hypertension, and to assess whether the effects depend on the number of health-care workers in the community.

Methods We used individual-level data from the 2005 Non-Communicable Disease Surveillance Survey (NCDSS) for fasting plasma glucose (FPG) and systolic blood pressure (SBP), body-mass index, medication use, and sociodemographic variables. Data for Behvarz-worker and physician densities were from the 2006 Population and Housing Census and the 2005 Outpatient Care Centre Mapping Survey. We assessed the effectiveness of treatment on FPG and SBP, and associations between FPG or SBP and Behvarz-worker density with two statistical approaches: a mixed-effects regression analysis of the full NCDSS sample adjusting for individual-level and community-level covariates and an analysis that estimated average treatment effect on data balanced with propensity score matching.

Results NCDSS had data for 65 619 individuals aged 25 years or older (11 686 of whom in rural areas); of these, 64 694 (11 521 in rural areas) had data for SBP and 50 202 (9337 in rural areas) had data for FPG. Nationally, 39·2% (95% CI 37·7 to 40·7) of individuals with diabetes and 35·7% (34·9 to 36·5) of those with hypertension received treatment, with higher treatment coverage in women than in men and in urban areas than in rural areas. Treatment lowered mean FPG by an estimated 1·34 mmol/L (0·58 to 2·10) in rural areas and 0·21 mmol/L (–0·15 to 0·56) in urban areas. Individuals in urban areas with hypertension who received treatment had 3·8 mm Hg (3·1 to 4·5) lower SBP than they would have had if they had not received treatment; the treatment effect was 2·5 mm Hg (1·1 to 3·9) lower FPG in rural areas. Each additional Behvarz worker per 1000 adults was associated with a 0·09 mmol/L (0·01 to 0·18) lower district-level average FPG (p=0·02); for SBP this effect was 0·53 mm Hg (–0·44 to 1·50; p=0·28). Our findings were not sensitive to the choice of statistical method.

Interpretation Primary care systems with trained community health-care workers and well established guidelines can be effective in non-communicable disease prevention and management. Iran's primary care system should expand the number and scope of its primary health-care worker programmes to also address blood pressure and to improve performance in areas with few primary care personnel.

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Introduction

Non-communicable diseases are important contributors to the burden of disease in countries at all stages of economic development. Although population growth and ageing have led to a rise in the absolute burden of such diseases, age-specific mortality and incidence of cardiovascular diseases and some other non-communicable diseases have decreased in high-income countries.[1,2] This success is at least partly attributable to the decrease in major risk factors, including smoking and high blood pressure and cholesterol.[2–5] However, the prevalence of these risk factors has increased or remained unchanged in many low-income and middle-income countries.[3–5]

Dietary, lifestyle, regulatory, and pharmacological interventions can lower major risk factors for cardiovascular disease, and are probably the reason behind population-level decreases in high-income settings.[6,7] However, the ability to identify people at high risk for cardiovascular disease, to deliver interventions, and to ensure compliance to these interventions is constrained by the number and cost of physicians and health facilities. Primary care might provide a cost-effective mechanism for the management of risk factors for cardiovascular disease in low-income and middle-income countries.[8] However, little evidence exists for whether health systems with low-to-medium budgets can use primary care for the management of risk factors for cardiovascular disease, especially in places where much of the population live in rural areas.[9] Also unclear is how the number of primary health-care workers—an important constraint in low-income and middle-income countries—can affect the effectiveness of the primary care system in the management of non-communicable disease and their risk factors. This absence of evidence is a major obstacle to the formulation of specific policies and plans for the control of non-communicable diseases, which are an important global health priority following the 2011 High-level Meeting of the UN General Assembly.

In this paper, we assessed how the Iranian rural primary health-care system, known as the Behvarz system, has contributed to the management of two major non-communicable diseases—hypertension and diabetes, which are both important risk factors for mortality and burden of disease in low-income and middle-income countries.[3,10] Cardiovascular disease and diabetes caused 53% of all adult deaths in Iran in 2006.[11] High blood pressure (which caused 80 000 annual deaths in 2005) and hyperglycaemia (which caused 34 000 annual deaths in 2005) are the leading metabolic risk factors for mortality in Iran.[11]

The Behvarz system uses community health workers to provide primary health care in rural Iran—areas with populations generally less than 5000 people and those with agriculture as the main economic activity. Community members with at least primary education are recruited into the Behvarz programme on the basis on their performance in an entrance examination. Newly appointed Behvarz workers undergo 2 years of classroom and practical training before beginning work in their own local community. Behvarz workers receive regular training throughout their career, a fixed salary that is about a sixth of that of physicians, and a performance-based bonus of no more than 5% of their salary. Between 1996 and 2002, the programme was expanded to incorporate diabetes prevention and control.[12] As a part of the protocol established by the National Plan for Prevention and Control of Diabetes, Behvarz workers are trained to identify high-risk groups—those aged 30 years or older who are pregnant, have a family history of diabetes, or are overweight. High-risk individuals are referred to physicians who visit the local community in so-called health houses for diabetes testing and, as required, treatment. Diagnosis, treatment, and lifestyle advice, as well as the date of the subsequent physician visit, are recorded by a Behvarz worker. Diagnosed patients obtain their subsidised drugs from the medical team visiting the health house. Behvarz workers then follow up patients with diabetes monthly to check that they are adhering to their treatment, to arrange for new drug supply, to examine them for symptoms of hyperglycaemia (eg, diabetic wounds and ulcers), and to refer patients with symptoms such as ulceration, painful limbs, and blurred vision to physicians at the rural health centres. The physicians to whom the patients are referred are expected to treat on the basis of well developed guidelines,[13] with patients advised by their local Behvarz worker to visit physicians at least once every 3 months. Behvarz workers are also responsible for holding training sessions on healthy diet and lifestyle for, among others, individuals who are at high risk for diabetes.[14] Although Iran has a programme for the management of hypertension, at the time of this study the programme did not have a specific role for Behvarz workers or detailed guidelines for physicians.

Methods

Data sources

We used data from the 2005 Non-Communicable Disease Surveillance Survey (NCDSS)[11,15] to measure the coverage of treatment for diabetes and hypertension, and to estimate the effectiveness of treatment in the reduction of fasting plasma glucose (FPG) and systolic blood pressure (SBP). We also combined NCDSS data and data for the density of Behvarz workers to examine whether a higher density of workers is associated with improved district-level outcomes—ie, lower mean FPG and SBP.

We used data for SBP and FPG from the 2005 NCDSS. The NCDSS included 89 400 individuals aged 15–64 years, by applying multistage systematic clustered sampling to create a representative sample of the rural and urban populations of each province.[15] We used data for participants aged 25 years or older for analysis (65 619 participants, of whom 11 686 lived in rural areas). The NCDSS included a questionnaire and physical and laboratory measurements of weight, height, and systolic and diastolic blood pressure (64 694 participants, 11 521 of whom lived in rural areas) and FPG (50 202 participants aged 25 years or older, of whom 9337 lived in rural areas, who attended the laboratory sessions). Participants were instructed to fast for at least 6 h; the mean fasting time reported at the time of laboratory test was 8·8 h (SD 2·2 h). The questionnaire included questions about drug use for different disorders, including hypertension and diabetes, confirmed visually by the interviewer as a part of the NCDSS protocol.

We used NCDSS data for individual-level sociodemographic data and the 2006 Population and Housing Census for employment rate, population, and the number of Behvarz workers for each district. For participants in the NCDSS, we calculated a wealth index with data for household assets. We obtained the number of physicians for each district from the 2005 Outpatient Care Centre Mapping Survey, and the number of critical-care beds in 2006 from the Ministry of Health databases. Whereas the Behvarz system operates in rural areas only, physicians serve the rural and urban populations of each district.

Diagnosis and treatment coverage

Respondents were classified as having diabetes if their FPG concentration was 7 mmol/L or lower, reported having been diagnosed with diabetes, or were taking glucose-lowering drugs. Respondents were classified as having hypertension if their SBP was 140 mm Hg or more, reported having been diagnosed with hypertension, or were taking drugs to lower their blood pressure. Diagnosis coverage was estimated as the proportion of people with diabetes or hypertension that reported having been diagnosed. Treatment coverage was estimated as the proportion of people with diabetes or hypertension who reported taking medication for their respective disorder. All prevalence and coverage estimates accounted for complex survey design. For rural-to-urban comparisons, prevalence was age-standardised with the national population in 2006.

Statistical analysis

We estimated the average effect of treatment on FPG and SBP for individuals with diabetes or hypertension by use of regression analysis with individual FPG or SBP as the dependent variable and treatment and its interaction with rural residency as the independent variable. We adjusted for individual age, sex, body-mass index, education, rural residency, and wealth index, as well as for survey sample weights. To account for unmeasured factors that might affect SBP or FPG, we used a mixed effects model, with a primary sampling unit (PSU)-level random intercept. The PSU-level random intercept and adjustment for sample weights also account for the complex survey design.

We estimated the effect of Behvarz-worker density (measured as per 1000 population aged 25 years or older) on FPG and SBP by use of a regression with the outcome variable as individual FPG or SBP and the independent variable as Behvarz-worker density. We adjusted for age, sex, body-mass index, education, marital status, and wealth index of individuals, as well as for district-level physician density, density of critical-care beds, and employment rate. To account for unmeasured factors at the district level that could affect population SBP or FPG, we used a mixed effects model, with a district-level random intercept. As above, we also included survey sample weights as a covariate and a PSU-level random intercept to account for complex survey design. We repeated the analyses, excluding districts with outlier Behvarz-worker and physician densities, using the Grubbs test (three districts for Behvarz-worker density and six districts for physician density); our findings were not sensitive to this exclusion (data not shown).

We did the above analyses on all individuals with SBP and FPG data in the NCDSS, accounting for potential confounding by individual and community characteristics through adjustment in a parametric model. The matching of individuals on the basis of individual and community characteristics is an alternative approach to account for differences between treatment and control groups in observational studies, with less rigid dependence on model specification.[16–18] We matched individuals with propensity scores based on individual and community characteristics.[16,17,19,20] We used matching with subclassification, in which groups with similar distributions of covariates are formed, because it helps improve balance of covariates, especially when the number of observations is large.[21]

After matching, we calculated average treatment effects, with all analyses accounting for subclassification.[20] Specifically, in the analysis related to treatment effectiveness, all individuals with diabetes or hypertension who were receiving treatment were matched to untreated patients with propensity scores based on their age, sex, body-mass index, education, and wealth index. In matched patients (all patients for both diabetes and hypertension analyses), we calculated the mean difference in FPG and SBP of those with and without treatment. In the analysis related to the associations of FPG and SBP with Behvarz-worker density, we first divided the districts into quartiles of worker density (≤1·4, 1·4–1·8, 1·8–2·3, and >2·3 per 1000 adult population). We

	Men (mean % [95% CI])	Women (mean % [95% CI])	Total (mean % [95% CI])
Diabetes			
Urban	7·5 (7·0–8·0)	9·5 (9·0–10·0)	8·5 (8·2–8·9)
Rural	4·9 (4·4–5·4)	6·4 (5·8–6·9)	5·6 (5·2–6·0)
Total	6·6 (6·2–7·1)	8·5 (8·1–8·9)	7·6 (7·5–7·7)
Hypertension			
Urban	16·5 (16·0–17·1)	20·3 (19·8–20·9)	18·4 (18·0–18·8)
Rural	14·4 (13·9–15·1)	20·1 (19·3–20·8)	17·2 (16·7–17·7)
Total	15·8 (15·2–16·4)	20·2 (19·8–20·7)	18·0 (17·9–18·1)

Table 1: **Age-standardised prevalence of diabetes and hypertension in Iran**

	Men (mean % [95% CI])	Women (mean % [95% CI])	Total (mean % [95% CI])
Diabetes			
Diagnosis coverage			
Urban	53·2 (50·4–56·0)	61·5 (59·1–63·9)	57·9 (56·1–59·8)
Rural	39·3 (35·0–43·6)	57·3 (53·6–60·9)	49·8 (46·9–52·6)
Total	49·7 (47·3–52·1)	60·4 (58·4–62·4)	55·8 (54·3–57·4)
Treatment coverage			
Urban	37·4 (34·6–40·1)	44·3 (41·8–46·7)	41·4 (39·5–43·2)
Rural	25·9 (22·1–29·7)	38·1 (34·5–41·7)	33·0 (30·4–35·7)
Total	34·5 (32·2–36·7)	42·6 (40·6–44·7)	39·2 (37·7–40·7)
Hypertension			
Diagnosis coverage			
Urban	38·4 (36·9–39·9)	61·9 (60·5–63·2)	51·2 (50·2–52·3)
Rural	30·3 (28·4–32·2)	55·7 (53·8–57·6)	44·5 (43·1–45·9)
Total	35·9 (34·7–37·1)	59·9 (58·8–61·1)	49·2 (48·3–50·0)
Treatment coverage			
Urban	27·5 (26·1–29·0)	46·6 (45·1–48·1)	38·1 (37·1–39·2)
Rural	20·0 (18·3–21·8)	39·8 (37·9–41·7)	31·3 (29·9–32·7)
Total	24·9 (23·8–26·1)	44·1 (43·0–45·3)	35·7 (34·9–36·5)

Table 2: **Diabetes and hypertension diagnosis and treatment coverage in Iran**

compared each of quartiles 2, 3, and 4 to quartile 1 (lowest density) to assess whether a dose-response relation existed. For each quartile, individual NCDSS records in quartile 1 of Behvarz-worker density (control) and the other three quartiles (treatment) were matched on the basis of age, sex, body-mass index, marital status, and wealth index, as well as their district's physician density, density of critical-care beds, and employment rate. For matched individuals (all those in both FPG and SBP analyses), we calculated the mean difference in FPG and SBP of those in the control and treatment groups. We also did a parametric analysis of matched data—ie, we ran regressions, adjusting for potential confounders, after matching.

All analyses were done separately for diabetes and hypertension. The mixed effects regressions were estimated with Stata/MP (version 11). We did matching and related post-matching analyses with MatchIt software (version 2.4-10), the methods for which are described in detail elsewhere.[16,20] Briefly, MatchIt calculates propensity scores with a logistic regression of treatment status for individual-level and community-level covariates, accounting for subclassification.

Role of the funding sources

There was no funding source for this study. FF had full access to all the data in the study and ME had final responsibility for the decision to submit for publication.

	Fasting plasma glucose		Systolic blood pressure	
	Coefficient (95% CI)	p value	Coefficient (95% CI)	p value
Treatment	–0·21 (–0·56 to 0·15)	0·249	–3·79 (–4·49 to –3·09)	<0·0001
Treatment interaction with residency in rural area	–1·13 (–1·81 to –0·46)	0·0001	1·28 (0·07 to 2·49)	0·038
Rural residence	0·50 (–0·13 to 1·13)	0·123	0·42 (–0·61 to 1·46)	0·424
Body-mass index	–0·09 (–0·12 to –0·06)	<0·0001	0·25 (0·20 to 0·31)	<0·0001
Sex				
Male	0		0	
Female	0·38 (0·05 to 0·71)	0·023	–0·40 (–1·01 to 0·22)	0·205
Age	–0·01 (–0·03 to 0·01)	0·191	0·30 (0·27 to 0·33)	<0·0001
Education				
Illiterate	0		0	
Primary school	–0·12 (–0·50 to 0·25)	0·514	–1·39 (–2·08 to –0·70)	<0·0001
Middle school	0·41 (–0·20 to 1·01)	0·188	–2·69 (–3·88 to –1·50)	<0·0001
High school	0·31 (–0·68 to 1·30)	0·541	–2·35 (–4·28 to –0·41)	0·018
Professional college	–0·34 (–0·92 to 0·24)	0·251	–3·35 (–4·50 to – 2·20)	<0·0001
University	–0·04 (–0·81 to 0·74)	0·927	–3·61 (–5·12 to –2·09)	<0·0001
Graduate	–1·41 (–3·03 to 0·21)	0·089	–2·22 (–5·50 to 1·07)	0·186
Wealth index	0·00 (–0·09 to 0·09)	0·996	–0·29 (–0·46 to –0·12)	<0·0001
Sample weight	0·002 (–0·001 to 0·004)	0·969	0·001(–0·001 to 0·003)	0·302
Constant	13·13 (11·64 to 14·62)	<0·0001	129·23 (126·46 to 132·00)	<0·0001

The coefficient of the term Treatment shows the treatment effect in urban areas; the interaction term between Rural residence and Treatment shows the differential effect of treatment in rural areas compared with urban areas.

Table 3: **Coefficients of regression to estimate the effect of diabetes and hypertension treatment on fasting plasma glucose and systolic blood pressure of treated individuals**

Results

Diabetes prevalence was higher in urban areas than it was in rural areas, whereas the difference between rural and urban areas for hypertension was small (table 1). The prevalence of both disorders was higher in women than it was in men (table 1).

About half of individuals with diabetes or hypertension had been diagnosed (table 2). Nationally, 39·2% (95% CI 37·7–40·7%) of those with diabetes and 35·7% (34·9–36·5%) of those with hypertension received medication, with higher treatment coverage in women than in men and in urban areas than in rural areas (table 2). In the mixed effects model, diabetes treatment lowered FPG by an estimated 1·34 mmol/L (0·58–2·10) in rural areas, but by only 0·21 mmol/L (–0·15 to 0·56) in urban areas (table 3). The estimated effect of hypertension treatment was a 2·5 mm Hg (1·1–3·9) lower SBP in rural areas and 3·8 mm Hg (3·1–4·5) lower SBP in urban areas.

In 2006, the density of Behvarz workers was generally higher in poorer districts, with the correlation between Behvarz-worker density and mean district wealth index being –0·22; the association between physician density and mean district wealth index was weak (correlation coefficient=0·02), possibly because newly graduated physicians in Iran serve in deprived areas for 3–7 years. An additional Behvarz worker per 1000 adults was associated with a 0·09 mmol/L (0·01–0·18) lower FPG on average in the mixed effects model (p=0·02; table 4). The associations between Behvarz-worker density and SBP were not only statistically insignificant (p=0·28) but also too small (<1 mm Hg) to have public health relevance (table 4). These results were not sensitive to whether we used Behvarz-worker density per 1000 population aged 25 years or older or Behvarz-worker density per 1000 total population. We recorded no association between physician density and FPG or SBP (this analysis was for rural areas only). In addition to the health system variables, age and body-mass index were strongly associated with FPG and SBP. Each decade of life was associated with an additional 0·22 mmol/L (0·19–0.27) higher FPG and 6·6 mm Hg (6·28–6·96) higher SBP; each additional body-mass index unit was associated with an additional 0·03 mmol/L (0·03–0·04) higher FPG and 0·85 mm Hg (0·78–0·92) higher SBP (table 4).

The above findings for treatment effectiveness and for the effect of Behvarz-worker density with mixed effects regression were consistent with the estimated average treatment effect of data balanced with propensity score matching. Specifically, average diabetes treatment effects were –1·47 mmol/L (–2·18 to –0·76) in rural areas and –0·26 mmol/L (–0·58 to 0·07) in urban areas after propensity score matching; average hypertension treatment effects were –3·5 mm Hg (–4·4 to –2·6) in rural areas and –4·9 mm Hg (–5·6 to –4·2) in urban areas. Running the mixed effects regression after

	Fasting plasma glucose		Systolic blood pressure	
	Coefficient (95% CI)	p value	Coefficient (95% CI)	p value
Individual level				
Body-mass index	0·03 (0·03–0·04)	<0·0001	0·85 (0·78 to 0·92)	<0·0001
Sex				
Male	–0·03 (–0·09 to 0·04)	0·395	3·13 (2·43 to 3·83)	<0·0001
Female	0	..	0	..
Age	0·02 (0·02 to 0·03)	<0·0001	0·66 (0·63 to 0·70)	<0·0001
Education				
Illiterate	0	..	0	..
Primary school	0·02 (–0·05 to 0·10)	0·538	–1·16 (–1·99 to –0·33)	0·006
Middle school	0·00 (–0·13 to 0·12)	0·940	–0·26 (–1·60 to 1·07)	0·698
High school	0·29 (0·04 to 0·53)	0·022	–1·59 (–4·13 to 0·96)	0·222
Professional college	0·21 (0·05 to 0·36)	0·011	0·07 (–1·59 to 1·74)	0·930
University	0·23 (–0·05 to 0·50)	0·105	–0·94 (–3·57 to 1·69)	0·483
Graduate	–0·14 (–0·55 to 0·26)	0·496	–1·32 (–5·92 to 3·29)	0·575
Married	–0·04 (–0·14 to 0·06)	0·429	–2·16 (–3·20 to –1·13)	<0·0001
Wealth index	0·02 (0·00 to 0·04)	0·020	–0·11 (–0·33 to 0·11)	0·326
District level				
Employment rate	–0·01 (–0·02 to 0·00)	0·054	–0·04 (–0·18 to 0·09)	0·541
Behvarz-worker density	–0·09 (–0·18 to –0·01)	0·023	0·53 (–0·44 to 1·50)	0·281
Physician density	0·04 (–0·07 to 0·15)	0·480	0·24 (–1·04 to 1·53)	0·711
Density of intensive-care-unit beds	0·01 (0·00 to 0·03)	0·090	0·09 (–0·10 to 0·28)	0·355
Sample weight	0·00 (–0·002 to 0·002)	0·989	0·004 (0·002 to 0·007)	<0·0001
Constant	4·50 (3·35 to 5·65)	<0·0001	72·39 (58·82 to 85·96)	<0·0001

Table 4: **Coefficients of regression to estimate the effect of Behvarz-worker density (per 1000 population aged 25 years or older) on fasting plasma glucose and systolic blood pressure in Iran**

matching changed the results very little compared with a simple mean difference, to –1·40 mmol/L (–2·08 to –0·68) in rural areas and –0·26 mmol/L (–0·59 to 0·08) in urban areas for FPG; SBP treatment effects were –3·6 mm Hg (–4·6 to –2·5) in rural areas and –5·2 mm Hg (–5·9 to –4·5) in urban areas. Increasing Behvarz-worker density from less than 1·4 workers per 1000 adults (quartile 1) to 1·4–1·8 workers per 1000 adults (quartile 2) had a small non-significant benefit on FPG concentrations (–0·23 mmol/L [–0·48 to 0·07]; figure). FPG concentrations improved with higher Behvarz-worker densities, reaching about –0·40 mmol/L in quartiles 3 and 4 (figure). We recorded no consistent benefit of higher Behvarz-worker densities for SBP (figure). After matching, adjustment for other covariates changed the results for different quartiles by no more than 0·02 mmol/L, none statistically significant, compared with mean difference.

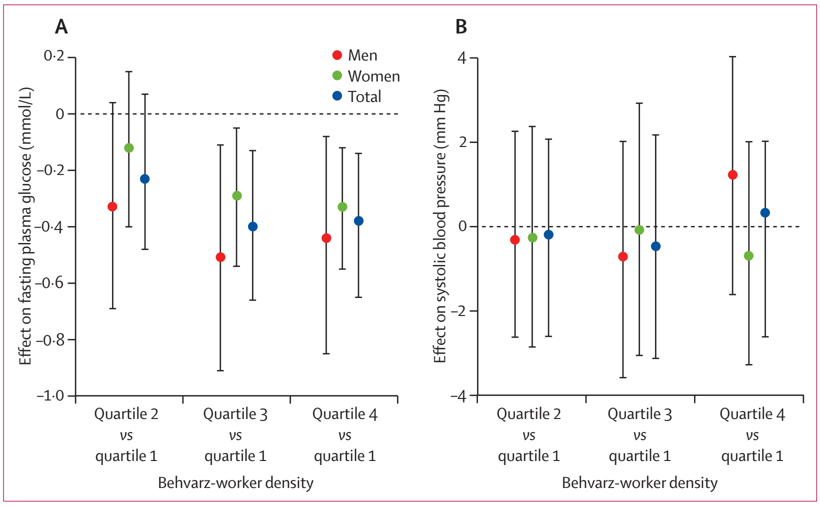

Figure: **Average effect of Behvarz-worker density on fasting plasma glucose (A) and systolic blood pressure (B)**
Quartile 1 is the lowest Behvarz-worker density and quartile 4 is the highest. A negative effect indicates lower risk factor level.

Discussion

In our nationally representative analysis, treatment of diabetes in Iran was more effective in rural areas than it was in urban areas. The diabetes treatment effect in rural and urban areas were, respectively, about 67% and 11% of the 2·0 mmol/L treatment effect in randomised trials.[22] The estimated hypertension treatment effects are less than half of that recorded in trials.[23] The difference between rural and urban areas was substantially smaller for hypertension treatment, with urban residents having a slightly more favourable outcome. We also noted that Behvarz-worker density was associated with lower FPG concentration, but it had no association with SBP.

The likely reason for the recorded difference in the effectiveness of Behvarz workers in the management of diabetes versus that of hypertension is that Iran has a National Diabetes Control and Prevention Programme, with specific roles for the Behvarz workers; the scope of the hypertension prevention and control programme is smaller and it did not have specific roles for Behvarz workers at the time of this study.[13,14,24] The diabetes programme guides physicians to give patients three types of treatment (metformin, sulphonylurea, or insulin). Possibly as important as the initial diagnosis and treatment, the Behvarz workers do monthly follow-ups to check that patients take their medication and visit physicians periodically or if they have symptoms of hyperglycaemia. Because there are no Behvarz workers in urban areas, patients' compliance with medication and regular visits to physicians depends on the patients themselves. The absence of such rigorous follow-up in urban areas might be the reason for lower effectiveness, despite slightly higher coverage and easier access to physicians.

The density of health-care workers has been associated with improved outcomes including infant and child, maternal, and adult mortality, and vaccination coverage.[25–28] Other studies did not find statistically significant association between the number of health-care workers and health outcomes (panel).[29–33] Most of these studies did cross-country analyses and few have considered the associations across small subnational units.[25] To our knowledge, none analysed the effects of health-care workers on risk factors for cardiovascular disease, especially with individual-level data.

Our study is a novel analysis of the association between primary health care and non-communicable diseases and risk factors. Other strengths of our study include use of a large representative health examination survey with high quality, measured data for individual-level risk factors and sociodemographic variables. NCDSS data together with data for health-care-worker density from census and administrative databases enabled analysis at the district level, which is essential for planning and resource allocation.

The main limitation of our analysis was the use of data from only one health examination survey. Repeated surveys would have allowed examination of not only the cross-sectional association but also the effect of change in Behvarz-worker density and other covariates with change in FPG and SBP; follow-up studies of individual patients with measurements before and after treatment would increase our confidence in the treatment effects. However, because our findings for the effect of worker density on glucose concentrations and blood pressure differ, residual confounding by their common risk factors is unlikely. Furthermore, we applied two distinct statistical approaches that control for potential confounding in different ways: mixed effects regression analysis of the full NCDSS sample and average treatment effect of data balanced with propensity score matching. Our conclusions about intervention effectiveness and about the effect of Behvarz-worker density were consistent between the two analyses, which increased our confidence in these findings. The NCDSS was restricted to adults aged 64 years or younger, which prevented us from analysing effects in older age groups, in which health-seeking behaviours and lifestyles might be different. However, according to the Population and Housing Census, only 4% of Iran's rural population are older than 65 years. We were unable to analyse the effects of the quality of Behvarz workers' management of patients or the role of health-care and transportation infrastructures on the effectiveness of risk-factor management. Finally, we did not measure treatment costs in this study because such data were not available.

Panel: Research in context

Systematic review

Our study focused on the management of non-communicable diseases and risk factors in primary health care, and how it might be affected by the number of primary care workers. We did not do a systematic review because all three topics covered (non-communicable disease management, primary care, and human resources for health) are very broad. We used reviews[9,26,37] and policy reports[38] to assess existing studies. We also searched PubMed for studies of human resources for health, focusing on only those that examined associations with health outcomes at the population level. We used the search terms ((("physicians"[Mesh]) OR "community health aides"[Mesh])) and ("health services research"[Mesh]), restricting our search to studies published in English, up to November, 2009. Previous reports have proposed that primary care can provide a cost-effective mechanism for the management of risk factors for cardiovascular disease in low-income and middle-income countries.[8,9] Some previous studies had assessed the management of non-communicable diseases at only the primary care clinic level,[39] but none had assessed a national programme. Previous studies of the association between the number of physicians and population health outcomes had noted that physician density is associated with improved outcomes, including infant and child, maternal, and adult mortality, and vaccination coverage.[25–28] Other studies have not recorded a statistically significant association between the number of health-care workers and health outcomes.[29–33] Most of these studies analysed relations across countries and few assessed the associations across small subnational units.[25] To our knowledge, none analysed the effects of health-care workers on risk factors for cardiovascular disease, especially with individual-level data or in a national study.

Interpretation

We assessed the coverage and effectiveness of treatment of hypertension in rural and urban areas of Iran, and examined how population mean FPG and SBP in rural areas are associated with the density of rural primary health-care workers. We found that diabetes treatment in Iran was more effective in rural areas than in urban areas. The difference between rural and urban areas was substantially smaller for hypertension treatment, with urban residents having a slightly more favourable outcome. We also found that the density of rural primary care workers was associated with lower FPG, but not with SBP. Our national study provides evidence for the proposition that non-communicable diseases and risk factors can be managed through the primary health-care system in middle-income countries. Our results are consistent with studies that recorded an association between the density of health-care workers and health outcomes, and extends these findings to non-communicable diseases and their risk factors, and to a subnational level.

The number of Behvarz workers by district in Iran was set when the programme started in 1985, and when they provided fewer services. Additional responsibilities over time, including diabetes prevention and control, possibly limit the time spent on each task when Behvarz-worker-density is low—such tasks include effective diabetes treatment follow-up, as indicated by the association between Behvarz-worker density and FPG. The different associations for Behvarz-worker and physician densities occurs because Behvarz workers are responsible for population-based prevention and control services, including diet and lifestyle education and follow-up on adherence to treatment on a regular basis, whereas physicians' roles are restricted to treatment prescription and less regular check-ups of individual patients on referral from Behvarz workers.

Despite its success in diabetes prevention and control, the absence of a national programme with well developed guidelines has rendered the Iranian primary health-care system virtually ineffective in lowering population blood pressure—the leading metabolic risk factor for mortality in Iran—despite the availability of individual and population-based interventions. Therefore, the Iranian primary health-care system has several challenges. First, the system needs to increase its scope so that it can have a more prominent role in diabetes diagnosis and address other non-communicable diseases. Although this extended focus can be on other non-communicable diseases and risk factors, such as hypertension, a more fundamental reform will shift the focus to the management of multiple risk factors—eg, strategies based on an absolute cardiovascular risk approach.[8] Furthermore, the systems needs to be prepared for better management of non-communicable diseases by increasing the number of Behvarz workers in areas where the number of workers is low. The assessment of the programme in Iran on the basis of repeated health examination surveys or even individual follow-up data, and the establishment of similar programmes elsewhere, can help provide evidence for its role as a method of population-based management of non-communicable diseases.

Although randomised studies have shown that diet, lifestyle, and clinical interventions can slow or even reverse hyperglycaemia and hypertension, compliance with treatment can be poor.[34] Our results suggest that the primary health-care system, with a sufficient number of health workers and a programme with well defined guidelines and individual follow-up of patients, can effectively manage chronic disorders such as diabetes, as postulated by researchers who have advocated a system similar to the directly observed treatment for tuberculosis for non-communicable diseases.[35] The role of health-care worker follow-up on treatment compliance recorded in this trial is consistent with the findings from such follow-up on compliance with antiretroviral treatment.[36] Our findings lend support to the feasibility of the integration of management of non-communicable diseases into the primary health-care system, especially in rural areas, through a system of trained community health-care personnel who are trained on and adhere to national treatment guidelines—an approach that might be more feasible, and perhaps more cost effective, than the training and employment of many physicians.

Contributors

FF, CJLM, TB, and ME designed the study. FF, CJLM, EG, and ME developed the analytic approach. HN, SA, GM, and AD worked on NCDSS design and data collection. FF did the analysis with input from all other authors. FF and ME wrote the first draft of the paper. All other authors contributed to the writing of the paper.

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Conflicts of interest

FF, SA, and AD participated in the integration of diabetes management in the Behvarz programme. All other authors declare that they have no conflicts of interest.

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