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REGULAR ARTICLES

Preventive factors related to brucellosis among rural population using the PRECEDE model: an application of path analysis

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Abstract
The purpose of this model-based study was to identify behavioral and environmental prevention factors for brucellosis and to determine the causal linkage among these factors in a rural area with high prevalence of the disease. A multi-stage random sampling method was used to select villages in Ahar County, located in East Azerbaijan Province, Iran. Participants ($n = 400$) were recruited from these villages. Data was collected in accordance with the PRECEDE model established in March 2016. This model consists of four phases intended to assess each participant's health and quality of life. Standardized, structured questionnaires exploring different aspects of brucellosis prevention (predisposing, reinforcing, enabling, environmental, and behavioral factors) were used. Path analysis was applied to assess the pathway structure of the PRECEDE model. Overall, the model fitted the data well ($\chi 2/df = 1.10$; RMSEA = .016 (CI 95%: 0.00–0.07), SRMR = .02, CFI = .99). Significant positive associations were found among predisposing, reinforcing, and enabling factors on the one hand, and behavior, on the other hand. The predisposing factors showed significant positive associations with general health, and the reinforcing factors and general health showed significant positive associations with health-related quality of life (HRQOL). The results of this study support the use of the PRECEDE model for brucellosis prevention, and suggest that a high level of general health, in combination with reinforcing factors can increase HRQOL in an area with a high prevalence of brucellosis.

Keywords Brucellosis · Path analysis · PRECEDE · Prevention

Introduction

Brucellosis is one of the most common and widely spread zoonotic diseases in developing countries (WHO 1997). It affects the health of both humans and livestock and has significant and measurable effects on the productive and reproductive performance of livestock (Corbel 2006). Brucellosis is an overlooked zoonotic disease that continues to present a major threat to public health, due to the physical suffering and reduced productivity experienced by infected members of the population (Franc et al. 2018). Prevention and control of the disease depends on minimizing the infection of humans and animals; this requires vigilant behavioral and environmental observation of the source of the infection (Musallam et al. 2016).

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Brucellosis is typically contracted directly, through environmental contact with (the contaminated tissue of) infected animals, or indirectly, through high risk behavior, such as the consumption of unpasteurized milk or dairy products produced by infected animals (Dean et al. 2012). Although many countries have seen major progress in the control and elimination of brucellosis, the incidence of human and animal brucellosis is still on the rise in Iran and the Middle East (Kafil et al. 2014). Iran's incidence of human brucellosis is among the five highest worldwide. Estimates of the frequency of brucellosis in Iran range from 0.5 to 10.9%, depending on the area (Green and Kreuter 2005); East Azerbaijan province has been established as the highest risk area in Iran (Nicoletti 2010).

Several factors seem to contribute to the routine failure of brucellosis control plans, but most of these reflect the inadequate attention to current behavioral and environmental factors, including the following: livestock health; the provision of subpar veterinary care; the availability of economic resources; the irregularity of animal vaccinations; human eating habits, such as (the frequency of and criteria for) dairy product consumption (Glaser et al. 2016); adherence to social and cultural customs; and socioeconomic status of a given population (Lai et al. 2017; Ragan et al. 2013). Review of the literature indicates that controlling brucellosis, especially on a regional scale, requires integrated action from both human and animal health sectors, alongside behavioral and environmental support (Glanz et al. 2008).

Most studies on brucellosis use statistical methods to examine associations; such studies often fail to apply a theoretical framework to provide analytical context. To prevent infections like brucellosis, it is necessary to employ a comprehensive and coherent framework to counter all essential elements of the disease. The PRECEDE model, described by Green and Kreuter, is a cost-benefit evaluation framework (Green and Kreuter 2005). According to this model, moderating a behavioral disease cannot be accomplished by targeting a single infected individual for analysis; instead, it is necessary to consider the entire surrounding environment, as well as all of the factors affecting the individual's behavior. As such, the model consists of several parts, including behavioral and environmental diagnoses, as well as educational and ecological assessments. The educational and ecological assessment itself is an effort to identify three kinds of critical factors: predisposing factors, enabling factors, and reinforcing factors (Glanz et al. 2008; Lindahl et al. 2015).

In order to determine, first, why East Azerbaijan (Iran) suffers the highest prevalence of brucellosis in the region, and second, which strategies could potentially reduce such prevalence, we designed a comprehensive study based on the PRECEDE model. To do so, a path model was developed to examine relationships among factors related to brucellosis. To construct our model, we needed to identify the most critical factors affecting the spread of brucellosis. Setting up an efficient program to control brucellosis required us to develop a meaningful and thorough understanding of the relevant rural population, it was crucial for us to understand the prevailing attitudes, behaviors, knowledge (i.e., conventional wisdom), as well as the related environmental factors.

In sum, the purpose of this model-based study was to identify the main behavioral and environmental factors for brucellosis prevention and control, to determine the causal linkage among these factors in a rural area with high prevalence of the disease. Figure 1 presents an overview of the associations.

Materials and methods

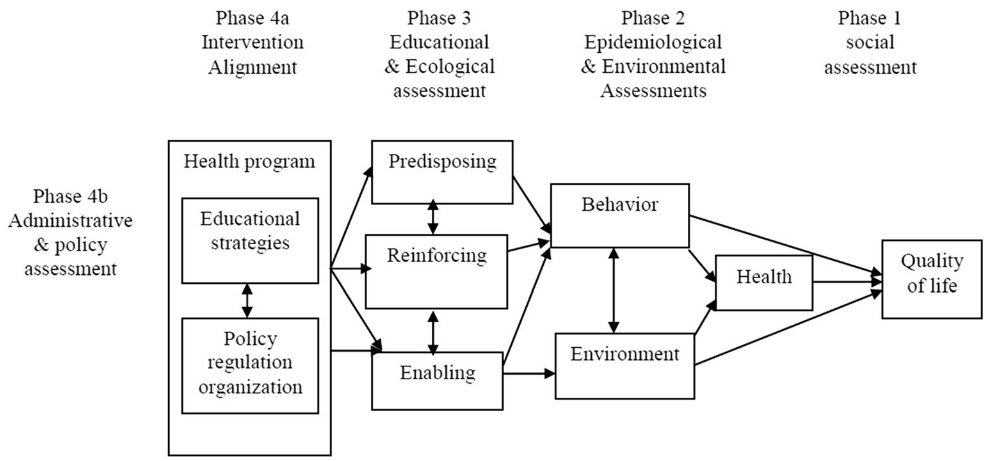
Study design

This cross-sectional study investigated factors related to the prevention and control of brucellosis, in a rural population in Ahar County, East Azerbaijan Province, Iran. We selected this area because the threat of brucellosis to public health in Ahar (Kafil et al. 2014) plays a significant role in the national economy, as well as in the HRQOL; as such, there is a critical need for a brucellosis prevention program in this region. We used a multi-stage random sampling method to select villages in the county. Ahar was stratified into four regions: North, South, West, and East. From each region, we selected two health centers, and from each of these centers, eight health houses served as health care facilities and had a high prevalence rate of brucellosis over the previous 2 years (Javanparast et al. 2011). We recruited participants using household health files from health houses in each village. In order to be included in our study, participants needed to be 15 years of age or older and resident in the villages for at least 6 months at the time of enrollment. Individuals who were employed in a health center or veterinary office or were unwilling to consent to data collection were ineligible for participation.

Data collection and measurements based on PRECEDE model-based scales for brucellosis prevention (PRECEDE-MSBP)

We intended to use our questionnaire to gather information from our target population about potential routes of transmission to humans, practices regarding the handling of aborted fetuses, and the processing and consumption of milk and dairy products. Data collection began on March 2016. We applied the PRECEDE model, which is an acronym for Predisposing, Reinforcing and Enabling Constructs in Educational Diagnosis and Evaluation (Green and Kreuter 2005). We used a standardized, structured questionnaire to measure the different factors for brucellosis prevention articulated by the PRECEDE model (Jahangiry et al. 2017).

Fig. 1 PRECEDE model-based scales for brucellosis prevention (PRECEDE-MSBP)



The first phase of the PRECEDE model consists of a social diagnosis, in which the health of the target population was assessed via the 12-item General Health Questionnaire (GHQ-12) (Montazeri et al. 2003) and an Iranian version of 12-item Short Form Health Survey (SF-12). The SF-12 is a very popular index of HRQOL among the general population (Montazeri et al. 2009). The psychometric properties of the Iranian version of the questionnaire have been well-documented (Montazeri et al. 2003, 2009).

The second phase of the PRECEDE model consists of a behavioral and environmental diagnosis. The environmental diagnosis scale included six items, each of which had five possible answers (1 = always, 2 = usually, 3 = sometimes, 4 = rarely, 5 = never); the scale is designed to assess the environmental characteristics that facilitate the actions, skills or resources required to prevent brucellosis. A sample item is as follows: "The rural district council provides us with a trunk for carrying out the animal wastes to the outside of the village."

The behavioral diagnosis scale included nine items, each of which had five possible answers (1 = always, 2 = usually, 3 = sometimes, 4 = rarely, 5 = never); the scale is designed to determine brucellosis-preventive behaviors among the rural population. A sample item is follows: "My family and I used to boil milk, for at least 5 minutes, before drinking." A higher total score reflected a higher level of brucellosis-preventive behaviors among the respondents.

The third phase of the PRECEDE model consists of an educational and ecological diagnosis. We used extensive literature review, as well as informal discussions with health workers, health care providers, experts on observation and control of brucellosis in health centers, veterinary specialists, and experts from agricultural organizations working on brucellosis in the targeted area. Activities resulted in the identification of problems or issues affecting brucellosis incidence, the appropriate measures for reducing the impact of the disease, and the changes needed to achieve brucellosis prevention. These factors can be classified as (a) predisposing, (b) enabling, and (c) reinforcing factors.

The *predisposing* subscale articulates reasons or motivations for performing a certain behavior. The subscale evaluated an individual's knowledge, attitudes, and self-efficacy about the prevention, transmission, and control of brucellosis. The *knowledge* subscale included 16 items, each of which had three-point responses ("Yes," "No," "I don't know"); these items bore on patients' knowledge about the causes of brucellosis, its modes of transmission, and appropriate preventive behaviors. A sample item is follows: "Brucellosis may be transmitted through breathing." The *attitudes* were measured through 17 items on a five-point Likert scale (ranging from 1 = strongly agree to 5 = strongly disagree). The *self-efficacy* subscale contained seven items, each of which had five-point responses (ranging from 1 = completely uncertain to 5 = completely certain). The scale assessed the respondents' beliefs about their abilities to perform brucellosis-preventive behaviors. A sample item is follows: "I am sure that I can wear a mask while working in the barn." The *reinforcing* subscale contained eight items, each of which had five possible answers (1 = always, 2 = usually, 3 = sometimes, 4 = rarely, 5 = never); this measured the respondents' perceptions of the role of social and familial support in the prevention of brucellosis.

Reinforcing factors refer to supporting groups, such as family members or friends, who help to take preventive measures against brucellosis. A sample item is as follws: "Have you ever been praised by the leaders or council in the village for proper disposal of livestock waste?"

The e*nabling* subscale consisted of five items, each of which had five possible answers (always, very often, sometimes, rarely, never); it measured the availability and accessibility of materials and resources to facilitate brucellosis-preventive behaviors. A sample item is following: "I have access to the stores of disinfectants/detergents."

Finally, all participants also responded to sociodemographic questions about their gender, age, marital status (single, married, divorced/widowed), educational qualifications (illiterate, primary, secondary, university degree), job status (employed, unemployed, student), personal history of brucellosis (yes/no), and family history of brucellosis (yes/no).

Sample size

The calculation of a priori sample size in this study was based on the recommendation that a sample size be more than 20 times the number of parameters in the path analysis [18]. According to the PRECEDE model (see Fig. 1), we had 17 paths; we calculated the minimum sample size accordingly (i.e., 17*20) and determined that we needed a minimum of 340 participants. However, a study with a power of 90%, at 5% significance level, would require approximately 400 participants (MacCallum et al. 1996). In order to increase the power of the analysis, we enlarged our sample size to 400 participants.

Analytic strategy

First, we provide the characteristics of the sample. Proportions are calculated in cases of categorical variables, and means with standard deviations are used in cases of continuous variables. We compared proportions using Pearson's chi-square test, and compared continuous variables using the independent *t* test. For all parameters, we defined 95% confidence intervals and studied the normality of distribution of scores using one sample Kolmogorov-Smirnov test.

Thereafter, according to the PRECEDE model, we used STATA, version 12.0 (Stata Corporation, College Station, TX, USA) to perform structural equation modeling (SEM), to facilitate analysis of the relationships among educational and ecological factors (predisposing, enabling, and reinforcing factors), behavioral and environmental factors, and the general health and HRQOL (Fig. 1). The arrows indicate the direction of the path, from exogenous variables (predisposing, enabling, and reinforcing factors) toward general health and HRQOL, via the mediating variables of behavior and environment. Because the variables in the analysis were not multivariate normally distributed (critical value for joint multivariate kurtosis was 3.78; i.e., higher than 3), we used the asymptotically distribution-free method (ADF) to estimate the parameters of the model (Finney and DiStefano 2006).

The fit of the structural equation model was assessed using various indices: chi-square ($\chi2$), the $\chi2$/df ratio, the goodness of fit index (GFI), the adjusted goodness of fit index (AGFI), the comparative fit index (CFI), the normed fit index (NFI), the relative fit index (RFI), the root mean square-error of approximation (RMSEA), and the standardized root-mean square residual (SRMR). If the $\chi2$ goodness of fit is not significant, the model is regarded as acceptable. Given that the $\chi2$ is almost always significant and not an adequate test of the model fit (Brown 2006), we report a $\chi\underline{2}$/df ratio as well. A $\chi2$/df ratio of less than two indicates an acceptable fit (Hox et al. 2017). When the values of CFI, NFI, RFI, and GFI approach 1, the model fit is acceptable, with a value of 0.95 or above indicating that the model provides a good fit, and a value of 0.90 indicating that the model provides an adequate fit. A value between 0 and 0.05 for SRMR indicates a good fit, and a value between 0.05 and 0.1 indicates an acceptable fit. Also, a value between 0 and 0.08 for RMSEA indicates a good fit (Maydeu-Olivares et al. 2018).

Standardized and unstandardized regression coefficients, as well as covariances between exogenous variables for the modified model were reported. Direct, indirect, and overall effects among the variables were estimated and presented on the modified model.

The sampling method was considered in our analysis by adjusting it is effect in the model.

Ethical considerations

The ethics committee of Tabriz University of Medical Sciences approved the study (number 5/4/7647). A signed informed consent form, explaining the study purposes, was obtained from all participants.

Availability of data and material The data collection tools and datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Results

The descriptive characteristics of the study sample are shown in Table 1. The mean (*SD*) age of the participants was 36.6 (11.4) years. Around 50.3% were males and 49.8% were females. The majority of men (58.8%) were farmers, and nearly all of the women (95.9%) were unemployed. Additionally, 8.5% of the participants reported a personal history of brucellosis, and 15% of the sample noted a family member who had suffered from the disease. Men reported significantly higher rates of personal brucellosis history than women did ($p < 0.05$).

The Cronbach's alpha value for the PRECEDE-MSBP factors ranged from low (0.44) to high (0.90). To assess univariate normality, we used a Kolmogorov-Smirnov test, which indicated that the knowledge, attitude, self-efficacy, social support, enabling, environmental, and behavioral scales were normally distributed. Hence, the mean of the scales was used as a measure of central tendency, and the standard deviation was used as a measure of variation. The mean Health-related

Table 1 Descriptive characteristics of the participants

	Total $n = 400$	Men $n = 201$	Women $n = 199$	p value
Age (mean, SD)	36.6 (11.4)	37.6 (11.8)	35.5 (11)	0.059
Education level (n, %)				0.001
Illiterate	35 (8.8)	12 (34.3)	23 (65.7)	
Primary	226 (56.5)	113 (23.5)	113 (23.5)	
Secondary	111 (27.7)	58 (52.2)	53 (47.5)	
University	10 (7)	6 (60.0)	4 (40.0)	
Marital status (n, %)				0.138
Single	36 (9.0)	16 (44.4)	26 (72.2)	
Married	351(87.7)	182 (51.8)	169 (48.2)	
Divorced/widowed	13 (3.3)	3	10	
Employment status (n, %)				< 0.0001
Farmer/agriculture	118 (58.8)	118 (100)	0	
Non-farmer	69 (17.3)	68 (98.5)	1 (1.5)	
Household	191 (47.7)	/	191 (100)	
Student	21 (5.3)	14 (66.6)	7 (33.4)	
History of brucellosis (yes, n %)	34 (8.5)	22 (64.8)	12 (35.2)	0.042
Family history of brucellosis (yes, n %)	60 (15)	30 (50.0)	30 (50.0)	0.539

quality of life scores with standard deviation are shown in Fig. 2.

The descriptive statistics of brucellosis control and prevention factors (e.g., predisposing, reinforcing, enabling, environmental, and behavioral) is shown in Table 2: the mean (SD) knowledge for men was 0.56 (SD = 0.26) and 0.6 (SD = 0.27) for women; the mean attitude for men was 3.7 (SD = 0.58) and 3.8 (SD = 0.27) for women; the mean self-efficacy for men was 3.7 (SD = 0.76) and 3.7 (SD = 0.63) for women; and the mean social support for men was 3.1 (SD = 0.5) and 3.7 (SD = 0.53) for women. The mean enabling, environmental, and behavioral factors were $M_{men} = 2.3$ ($SD_{men} = 0.65$) and $M_{women} = 2.3$ ($SD_{women} = 0.66$), for M_{men} 2.1 ($SD_{men} = 0.37$) and $M_{women} = 2.1$ ($SD_{women} = 0.42$), and for M_{men} 3.1 ($SD_{men} = 0.52$) and $M_{women} = 3.2$ ($SD_{women} = 0.5$), respectively.

More than half of the participants (56.5%) had a primary education, while 9.5% had a secondary and a university education, and 10% were illiterate: the mean attitude of illiterate participants was 0.55 (SD = 0.27); that of primary-educated participants was 0.57 (SD = 0.26); that of secondary-educated participants was 0.6 (SD = 0.28); and that of participants with university education was 4.2 (SD = 0.48). The mean self-efficacy according to education was as follows: that of illiterate participants was 3.5 (SD = 0.73); that of participants with a primary education was 3.6 (SD = 0.67); that of participants with a secondary education 3.8 (SD = 0.68); and that of participants with

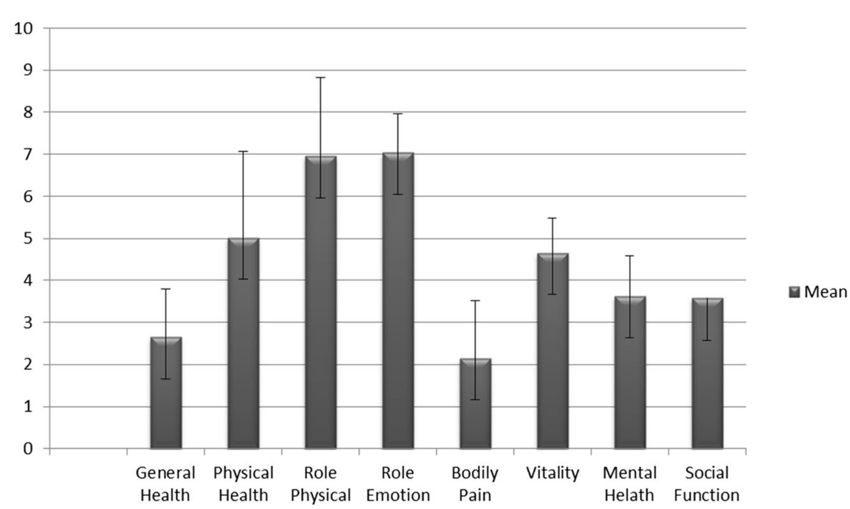


Fig. 2 Health-related quality of life scores with standard deviation

Table 2 Brucellosis control and prevention predisposing, reinforcing, enabling, environmental, and behavioral factors

	Knowledge mean (SD)	Attitude mean (SD)	Self-efficacy mean (SD)	Social support mean (SD)	Enabling mean (SD)	Environmental mean (SD)	Behavioral mean (SD)
Total (*n* = 400)	58.74 (0.3)	3.82 (0.61)	3.76 (0.75)	3.23 (0.57)	2.34 (0.64)	2.18 (0.40)	3.24 (0.52)
Age							
≤ 35 (*n* = 203)	0.61 (0.27)	3.85 (0.60)	3.64 (0.66)	3.27 (0.61)	2.33 (0.69)	2.14 (0.42)	3.27 (0.57)
36–50 (*n* = 151)	0.56 (0.25)	3.72 (0.53)	3.71 (0.64)	3.15 (0.50)	2.36 (0.54)	2.12 (0.47)	3.22 (0.50)
≥ 51 (*n* = 46)	0.56 (0.30)	3.66 (0.69)	3.43 (0.81)	3.44 (0.80)	2.15 (0.71)	2.14 (0.44)	2.16 (0.42)
p value	0.19	0.047	< 0.0001	0.82	0.031	0.73	0.023
Gender							
Male	0.56 (0.26)	3.77 (0.58)	3.71 (0.76)	3.12 (0.57)	2.34 (0.65)	2.13 (0.37)	3.18 (0.52)
Female	0.63 (0.27)	3.85 (0.56)	3.71 (0.63)	3.74 (0.53)	2.37 (0.66)	2.15 (0.42)	3.29 (0.50)
p value	0.047	0.76	0.003	0.035	0.878	0.025	0.723
Education							
Illiterate (*n* = 35)	0.55 (0.27)	3.73 (0.63)	3.56 (0.73)	3.37 (0.46)	2.33 (0.62)	2.27 (0.52)	3.29 (0.53)
Primary (*n* = 226)	0.57 (0.26)	3.71 (0.52)	3.63 (0.67)	3.24 (0.56)	2.38 (0.67)	2.11 (0.40)	3.17 (0.40)
Secondary (*n* = 11)	0.60 (0.28)	3.85 (0.64)	3.87 (0.68)	3.25 (0.46)	2.36 (0.65)	2.01 (0.34)	2.06 (0.34)
University (*n* = 28)	0.76 (0.2)	4.22 (0.48)	4.34 (0.54)	3.22 (0.38)	2.55 (0.60)	2.21 (0.38)	2.27 (0.38)
p value	0.004	0.001	< 0.0001	0.47	0.33	0.301	0.001
Employment status							
Farmer/ agriculture	0.57 (0.27)	3.63 (0.55)	3.52 (0.77)	3.14 (0.55)	2.34 (0.63)	2.27 (0.40)	3.05 (0.51)
Unemployed	0.55 (0.25)	3.81 (0.61)	3.80 (0.68)	3.22 (0.42)	2.37 (0.69)	2.12 (0.39)	3.22 (0.49)
Household	0.60 (0.28)	3.87 (0.56)	3.61 (0.62)	3.25 (0.54)	2.36 (0.66)	2.10 (0.35)	3.24 (0.49)
Student	0.65 (0.22)	4.15 (0.53)	4.37 (0.61)	3.33 (0.38)	2.54 (0.68)	2.13 (0.32)	3.55 (0.65)
p value	0.298	0.007	< 0.0001	0.102	0.484	0.614	0.001
Family member							
≤ 4 (*n* = 220)	0.62 (0.27)	3.84 (0.58)	3.76 (0.67)	3.37 (0.56)	2.34 (0.61)	2.13 (0.38)	3.35 (0.55)
5–8 (*n* = 176)	0.54 (0.26)	3.72 (0.55)	3.60 (0.73)	3.16 (0.53)	2.31 (0.71)	2.14 (0.47)	3.01 (0.51)
> 8 (*n* = 4)	0.25 (0.18)	3.45 (0.39)	2.74 (0.55)	2.97 (0.57)	2.50 (1)	1.67 (0.25)	2.81 (0.58)
p value	0.001	0.003	0.013	0.002	0.898	0.006	< 0.0001
History of brucellosis							
Yes (*n* = 34)	0.73 (0.22)	4.00 (0.53)	3.74 (0.79)	3.3 (0.49)	2.56 (0.66)	2.25 (0.41)	3.23 (0.52)
Yes (*n* = 366)	0.57 (0.27)	3.70 (0.57)	3.73 (0.69)	3.2 (0.52)	2.33 (0.65)	2.19 (0.39)	3.26 (0.51)
p value	0.002	0.510	0.243	0.933	0.663	0.926	0.753
Family history of brucellosis							
Yes (*n* = 60)	0.67 (0.27)	3.93 (0.52)	3.78 (0.76)	3.26 (0.49)	2.45 (0.65)	2.10 (0.40)	3.14 (0.53)
No (*n* = 340)	0.57 (0.26)	3.74 (0.58)	3.71 (0.69)	3.24 (0.53)	2.32 (0.66)	2.11 (0.40)	3.28 (0.51)
p value	0.007	0.07	0.48	0.58	0.07	0.79	0.83

university education was 4.3 (SD = 0.54). There were statistically significant differences between men and women in the mean scores on knowledge, attitudes, and social support. Younger participants (< 50 years) had higher mean scores for attitudes, self-efficacy, perceived social support, and enabling factors related to prevention and control of the brucellosis. These younger participants also indicated better practices than others for prevention and control of brucellosis. The primary-educated and illiterate participants had significantly lower mean scores than others for knowledge, attitude, and self-efficacy ($p < 0.05$). The mean scores of all variables are shown in Table 2.

The correlation matrix for knowledge, attitude, self-efficacy, reinforcing, enabling, environmental, and behavioral factors, as well as general health and HRQOL is shown in Table 3. Significant positive correlations are found between general health, on the one hand, and knowledge, attitude,

Table 3 Correlation matrix for variables

	1	2	3	4	5	6	7	8	9
1. Knowledge	1								
2. Attitude	0.646**	1							
3. Self-efficacy	0.338**	0.492**	1						
4. Reinforcing	0.117*	0.254**	0.046	1					
5. Enabling	0.186*	0.275**	0.169**	0.160**	1				
6. Environment	− 0.024	− 0.055	0.027	− 0.107*	− 0.017	1			
7. Behavior	0.202**	0.385**	0.338**	0.422**	0.378**	− 0.167**	1		
8. General health	0.142**	0.218**	− 0.081	0.100*	0.052	− 0.113*	0.071	1	
9. HRQOL	0.157**	0.237**	− 0.027	0.293**	0.048	− 0.143**	0.149**	0.361**	1

**$p < 0.001$, *$p < 0.01$

reinforcing factors, on the other hand. A significant negative association was found between general health and environmental factors. Furthermore, HRQOL was positively associated with knowledge, attitude, reinforcing behavior, and general health; it was negatively associated with environmental factors.

Path analysis was conducted to evaluate the pathway structure of the PRECEDE model (Fig. 1). The result showed that the path analysis for the initial model did not fit our data well: ($\chi2$ (7) = 52.91, $p < .001$; $\chi2$/df = 7.56; RMSEA = .12 (CI 95 %: 0.09–0.16); SRMR = .13; CFI = .76; GFI = .96; AGFI = .86; NFI = .75; and RFI = .25. Therefore, in accordance with the original PRECEDE model (7), we added direct paths from predisposing, reinforcing, enabling, behavior, and environmental factors to HRQOL and general health. The fit of the model improved significantly with the addition of these paths to the original model: $\chi2$ (5) = 5.50, ns; $\chi2$/df = 1.10; RMSEA = .016 (CI 95%: 0.00–0.07); SRMR = .02; CFI = .99; GFI = .99; AGFI = .98; NFI = .97; and RFI = .89. According to the goodness of fit measures, it is possible to conclude that the modified model has a good fit.

Beta and standard beta for the model are shown in Table 4. The analyses revealed a significant positive association between predisposing factors and general health, indicating that greater knowledge and more positive attitudes about prevention, transmission, and control of brucellosis leads to changes in general health. Furthermore, a significant positive association was found between reinforcing factors and HRQOL, indicating that support from family or friends may lead to changes in general health and HRQOL. As expected, a significant positive association was also found between general health and HRQOL. In

Table 4 Coefficient and standardized coefficient of regression for fitted model

	Independent variables	Beta (CI 95%)	Standardized beta (CI)	*p* value	Dependent variable
1	Behavior	− 0.218 (− 1.184, 0.741)	− .0212 (− .118, .074)	0.651	General health
	Environment	− 1.661 (− 3.100, − .322)	− .130 (− .237, − .0235)	0.0152	
	Predisposing factors	0.763 (0.358, 1.172)	.189 (.088, .290)	< 0.001	
2	General health	0.271 (0.201, 0.343)	.337 (.258, .416)	< 0.001	HRQOL
	Behavior	− 0.056 (− 0.790, 0.690)	− .006 (− .096, .084)	0.891	
	Environment	− 0.849 (− 1.773, 0.121)	− .07 (− .169, .011)	0.080	
	Reinforcing	2.098 (1.325, 2.886)	.256 (.168, .344)	< 0.001	
3	Environment	− 0.019 (− 0.223, 0.196)	− 0.015 (− 0.17, .14)	0.850	Behavior
	Predisposing factors	0.112 (0.076, 0.144)	.278 (.020, .352)	< 0.001	
	Reinforcing	0.331 (0.240, 0.423)	.336 (.253, .420)	< 0.001	
	Enabling factors	0.184 (0.121, 0.253)	.242 (.156, .327)	< 0.001	
4	Behavior	− 0.135 (− 0.313, 0.043)	− .17 (− .39, .05)	0.135	Environment
	Enabling factors	0.026 (− 0.051, 0.110)	.043 (− .08, .173)	0.512	
5	Cov (reinforcing, predisposing)	0.118 (0.052, 0.18)	.177 (.085, .270)	0.001	
6	Cov (enabling, reinforcing)	0.215 (0.13, 0.29)	.252 (.160, .344)	< 0.001	
7	Cov (enabling, predisposing)	0.055 (0.019, 0.091)	.161 (.059, .262)	0.002	

Cov covariance

Table 5 Unstandardized direct, indirect, and total effect between the variables in modified model

Dependent	Independent	Direct effect (CI 95%)	*p*	Indirect effect (CI 95%)	*p*	Total effect (CI 95%)	*p*
General health	Behavior	− 0.218 (− 1.184, 0.741)	0.651	0.224 (− 0.060, 0.526)	0.091	0.008 (− 1.013, 1.020)	.980
	Environment	− 1.661 (− 3.100, − 0.322)	0.0152	0.000 (− 0.001, 0.001)	0.850	− 1.661 (− 3.00, − .320)	.015
	Predisposing	0.763 (0.358, 1.172)	< 0.001	0.001 (− 0.113, 0.110)	0.980	0.768 (0.380, 1.141)	< 0.001
	Reinforcing	No path	–	0.002 (− 0.342, 0.343)	0.980	.002 (− .343, .341)	.980
	Enabling	No path	–	− 0.041 (− 0.250, 0.159)	0.691	− 0.042 (− 0.250, 0.169)	0.691
HRQOL	General health	0.271 (0.210, 0.343)	< 0.001	No path	–	0.280 (0.211, 0.347)	< 0.001
	Behavior	− 0.056 (− 0.790, 0.690)	0.891	0.110 (− 0.243, 0.461)	0.523	0.063 (− 0.780, .919)	0.880
	Environment	− 0.849 (− 1.773, 0.121)	0.080	− 0.461 (− 0.833, − 0.092)	0.014	− 1.281 (− 2.311, − 0.272)	0.013
	Predisposing	No path	–	0.209 (0.071, 0.362)	0.003	0.225 (0.071, 0.362)	0.003
	Reinforcing	2.098 (1.325, 2.886)	< 0.001	0.023 (− 0.261, 0.313)	0.880	2.122 (1.383, 2.851)	< 0.001
	Enabling	No path	–	− 0.020 (− 0.182, 0.145)	0.789	− .026 (− .187, .145)	.791
Behavior	Behavior	No path	–	0.002 (− 0.001, 0.006)	0.135	.002 (− .001, .006)	.131
	Environment	− 0.019 (− 0.223, 0.196)	0.850	− 0.000 (− 0.001, 0.000)	0.858	− .0191 (− .231, .180)	.854
	Predisposing	0.112 (0.076, 0.144)	< 0.001	0.000 (− 0.002, 0.003)	0.843	0.112 (0.081, 0.147)	< 0.001
	Reinforcing	0.331 (0.240, 0.423)	< 0.001	0.001 (− 0.007, 0.009)	0.840	0.331 (0.240, 0.425)	< 0.001
	Enabling	0.184 (0.121, 0.253)	< 0.001	− 0.000 (− 0.001, 0.001)	0.970	0.190 (0.120, 0.261)	< 0.001
Environment	Environment	No path	–	0.002 (− 0.020, 0.031)	0.851	.002 (− .020, .031)	.850
	Behavior	− 0.135 (− 0.313, 0.043)	0.130	− 0.000 (−0.001, 0.000)	0.135	− 0.145 (− 0.315, 0.042)	0.131
	Predisposing	No path	–	− 0.015 (− 0.035, 0.005)	0.147	− .015(− .035, .005)	0.140
	Reinforcing	No path	–	− 0.045 (− 0.110, 0.017)	0.166	− .045 (− .110, .017)	.166
	Enabling	0.026 (− 0.051, 0.110)	0.512	− 0.023 (− 0.051, 0.008)	0.144	.001 (− .062, .063)	.980

addition, the predisposing, reinforcing, and enabling factors showed significant positive associations with behavior. The indirect and direct effects of variables are shown in Table 5.

Discussion

This study proposed and evaluated a PRECEDE model for the prevention and control of brucellosis among a rural population. The PRECEDE model (Glanz et al. 2008) includes predisposing (knowledge, attitudes, and self-efficacy), reinforcing (social support), enabling, environmental and behavioral factors.

Significant differences were found between men and women on knowledge, self-efficacy, social support, and environmental perceptions of the prevention and control of brucellosis. Although most of the male participants (58.8%) were farmers (employed in the agricultural industry) with more exposure to the potential risk factors for brucellosis (such as interacting with animals), they had less information and lower levels of self-efficacy, perceptions of social support, and environmental factors than females did about the prevention of brucellosis. Similar results have been found in a study conducted in Tajikistan (Lindahl et al. 2015). Given that farmers are at particularly high risk of contracting brucellosis, increasing their knowledge and perceptions of brucellosis is crucial to increasing control over its transmission in animals and humans (El Idrissia 2014). In addition to individual perception and understanding of the transmission routes of brucellosis, the ability to use and availability of personal protective equipment, such as gloves and masks, when exposed to probably-infected animals, are seen as more important (Shang 2000). Providing environmentally-appropriate facilities, skills, or resources to prevent brucellosis among the rural population can also have a prophylactic effect on the disease (Ragan et al. 2013). Furthermore, sufficient collaboration and partnership between farmers and the agriculture and health sectors have been recognized as main modes for reducing the disease. As the economic costs of prevention programs, such as vaccinating, testing and slaughtering are very high, these programs cannot succeed without collaboration among the different rural communities (Sofian et al. 2008).

In our study, behavioral prevention was positively associated with knowledge, self-efficacy, and attitude, as well as reinforcing, and enabling factors. However, environmental factors were significantly and inversely related to behavioral factors. One explanation for this is poorly developed perception of environmental risk factors, but another, equally sound, one is lack of access to a supportive environment. Smits (Smits 2013) confirmed that public health services can assist in encouraging acceptance of control programs by creating awareness of brucellosis. To reduce costs, brucellosis control programs can be combined with other veterinary or public health activities or interventions.

This study implemented the PRECEDE model to identify preventive determinants of brucellosis and its relation to health and HRQOL. The pathway analyses suggest that a change in general health and reinforcing factors directly affect HRQOL. Furthermore, predisposing, reinforcing, and enabling factors are directly related to protective behavior. This study further shows that a high level of general health and reinforcing factors can increase HRQOL in an area with high prevalence of brucellosis. Also, high levels of predisposing and reinforcing factors can improve brucellosis-related behavior. Reinforcing factors, such as social support, may provide necessary rewards or incentives to continue behaviors (Green and Kreuter 2005). A literature review revealed that family members and relatives provide financial and practical support for adopting protective behavior (Mamdani and Bangser 2004). Social support has also been recognized as an important factor in the facilitation of healthy behavior (Kansiime et al. 2014).

Brucellosis is endemic in certain parts of Iran. The prevalence of brucellosis in Iran has been reported as 0.5 to 10.9% in different provinces (Sofian et al. 2008). There is evidence that village inhabitants and family household members play primary roles in control the disease and should thus have sufficient knowledge and environmental support for the prevention of brucellosis (Smits 2013). Health education programs should pay particular attention to behavioral and environmental factors related to brucellosis transmission.

Findings of this study can be interpreted with caution. As the PRECEDE Model was used in a population with high prevalence of brucellosis, so it is not clear such a model will be suitable areas with low prevalence of brucellosis.

Conclusion

Overall, the results of this study support the PRECEDE model for brucellosis prevention. The findings revealed that a high level of general health, combined with reinforcing factors, can increase HRQOL in an area with high prevalence of brucellosis.

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Authors' contributions LJ was the study's supervisor and contributed to all aspects of the study and provided the manuscript. BM collected the data. PS conducted the analysis, MKH have helped and consulted us in data gathering process. KP contributed substantially to the data interpretation and critically revised the final article for important intellectual content. All authors read and approved the paper.

Compliance with ethical standards

Ethical approval Informed consent was obtained from all participants. The study received ethical approval from the Ethics Committee of Tabriz University of Medical Sciences (NO: IR. TBZMED. REC. 1394. 596).

Consent for publication The authors have agreed on the content of the manuscript.

Conflict of interest The authors declare that they have no conflicts of interest.

Abbreviations HR, health-related; QOL, quality of Life; PRECEDE-MSBP, PRECEDE model-based scales for brucellosis prevention; SEM, structural equation modeling; ADF, asymptotically distribution-free method; GFI, goodness of fit index; AGFI, adjusted goodness of fit index; CFI, comparative fit index; NFI, normed fit index; RFI, relative fit index; RMSEA, root mean-square error of approximation

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