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Measures of Maternal Socioeconomic Status in Yemen and Association with Maternal and Child Health Outcomes

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Abstract *Background* Reliable measurement of socioeconomic status (SES) in health research requires extensive resources and can be challenging in low-income countries. We aimed to develop a set of maternal SES indices and investigate their associations with maternal and child health outcomes in rural Yemen. *Methods* We applied factor analysis based on principal component analysis extraction to construct the SES indices by capturing household attributes for 7295 women of reproductive age. Data were collected from a sub-national household survey conducted in six rural districts in four Yemeni provinces in 2008–2009. Logistic regression models were fitted to estimate the associations between the SES indices and maternal mortality, spontaneous abortion, stillbirth, neonatal and infant mortality. *Results* Three SES indices (wealth, educational and housing quality) were extracted, which together explained 54 % of the total variation in SES. Factor scores were derived and categorized into tertiles. After adjusting for potential confounding factors, higher tertiles of all the indices were inversely associated with spontaneous abortion. Higher tertiles of wealth and educational indices were inversely associated with stillbirth, neonatal and infant mortality. None of the SES indices was strongly associated with maternal mortality. *Conclusion* By subjecting a number of household attributes to factor analysis, we derived three SES indices (wealth, educational, and housing quality) that are useful for maternal and child health research in rural Yemen. The indices were worthwhile in predicting a number of maternal and child health outcomes. In low-income settings, failure to account for the multidimensionality of SES may underestimate the influence of SES on maternal and child health.

Keywords Socioeconomic status · Factor analysis · Maternal and child health · Yemen

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Significance

What is already known on this subject? In attempt to describe SES and its influence on health, most previous studies from low- and middle-income settings have utilized individual level socioeconomic factors or employed indicators that measure only some components of SES or their proxies, which may fail to capture the multidimensionality of SES.

What this study adds? By subjecting a number of household attributes to factor analysis we developed three SES indices for reproductive age Yemeni women, which are worthwhile for studying the influence of SES on maternal and child health outcomes. These indices are also a good benchmark for application in other contexts.

Introduction

Socio-economic status (SES) is a challenging concept, both in definition and measurement [1]. The importance of SES as a health determinant is well known in both developing and developed countries [1–5]. In developed countries individual or household level SES is traditionally measured as a combination of occupation, income, and education [3, 6]. However, precise and reliable measures of SES appear to be deficient and there is difficulty with the gathering of individual SES data [5, 7–10].

In low- and middle-income countries, particularly in rural settings, most people have limited education and income tends to be unstable and is not clearly ascertained in terms of numbers [1]. Furthermore, the SES in such settings is mostly subjected to a relative social and family positions and this is not often revealed in asset ownership [1, 11]. In order to overcome the challenges of reliably measuring SES in rural low- and middle-income settings, researchers have utilized proxy measures for describing SES, particularly when SES is measured by a proxy of one of its components, for example by income only, wealth, or education [12]. Along these lines, several investigators have predicted health outcomes focusing on single variables as proxies of SES, such as education and occupation [13, 14].

SES is a multidimensional construct that constitutes factors at the personal, household and community levels [3, 15]. The level in inequality within and between dimensions of SES differs as well [15]. Different health consequences across groups can be formed by interaction of SES with other social features, such as ethnic group, language accent, gender, and so forth [3]. Consequently, inadequately measuring SES factors will undermine the capturing of the complex and multifactorial nature of SES [3].

In rural Yemen there is no reference index that can be used to provide meaningful measure of women's SES, which can facilitate research on the association between SES and health in these settings. As in other low- and middle-income countries, measuring women SES has many challenges as most women are in unpaid employment, hence quantitatively recorded data to measure their SES are almost unavailable [16]. In addition female illiteracy rate is high (76 %) and the culture of male inheritance and authority over women persist [17]. In the absence of an existing SES index, we took advantage of the opportunity provided by a recent household survey in rural Yemeni districts to construct SES indices for rural Yemeni women by subjecting various SES measures to factor analysis, which can be further employed in maternal and child health research. In addition, we aimed to examine the associations between the constructed SES indices and a number of maternal and child health outcomes.

Methods

Design and Study Setting

This study is based on data from the sub-national household cross-sectional survey conducted in six rural districts of four provinces in Yemen in 2008–2009. The survey was conducted to provide baseline data on maternal and child health and related issues in order to explore possible ways and strategies to improve maternal and child health care in rural Yemen. The survey was undertaken under the scheme of the Home Based Maternal and Neonatal Care project carried out by UNICEF.

Four sub-national governorates and the six rural districts were chosen based on their poverty levels (according to Yemen national categorization), where a list of 42 sub-districts was made and 26 of these were chosen. Next, 213 villages were randomly selected from the 26 sub-districts and all households in the selected villages were eligible to be included in the survey. Altogether 7341 households were contacted for interview and 7295 women of reproductive age from these households were interviewed. The interview was done face-to-face in Arabic and was conducted by trained midwives who work in the health services of the same areas. The interview instrument was a 64-item structured questionnaire, which was initially piloted in the study setting and observed changes were accordingly made prior to the main survey. The questionnaire gathered information on participants' socioeconomic and demographic characteristics, women's reproductive characteristics, maternal health care utilization during the last pregnancy, childbirth and maternal mortality, as well as neonatal and infant mortality.

Ethical approval was obtained from the Ministry of Health, Health Research Center, Yemen. In addition, ethical approval for the project was obtained from UNICEF-Yemen review committee.

Socioeconomic Measures

Data on a number of items representing the socioeconomic measures of the participants were collected during the interview, including data on ownership of vehicle (motorcycle, automobile [care/bus/truck], farm wagon, other); ownership of agricultural land; ownership of livestock; household access to basic service (e.g. main source of drinking water, water fetching time, electricity type, toilet type); characteristics of place of dwelling (type of house [separate, shared], outer wall material type [concrete, wood or metal, other]); and household head level of education [18].

Statistical Analysis

SES Indices

We constructed the SES indices by subjecting the above-named socioeconomic variables to a factor analysis using principal component analysis (PCA) as the extraction method. The factor analysis was undertaken based on assigned scores and the presence or absence of items from a list of household assets as was adapted in previous studies [19]. We used varimax (orthogonal) rotation with Kaiser Normalization. Eigenvalues > 1 was used as the criteria for extraction, which was then confirmed by a scree plot test.

Interpretation of the rotated components was based on the magnitude of the loading of variables on each component, so that a variable was said to load on a component if its factor loading was $\geq \pm 0.40$ for that component and was $< \pm 0.40$ for the other components. In order to compute the factor scores, we added together the values of a subject on the variables loading on a component and weighted these by the factor scores of the corresponding component. The factor scores of each index were then divided into tertiles and these were used for further analyses.

Associations Between SES Indices and Maternal and Child Health Indicators

We applied logistic regression to analyzed the associations between each of the SES indices and maternal and child health status (maternal mortality, spontaneous abortion, stillbirth, neonatal and infant mortality). Adjusted associations were computed by adjusting for tobacco use, chewing qat, consanguinity, family marriage, underage marriage, family planning, and antenatal care. The estimated odds ratios were accompanied by their respective 95 % confidence intervals. Statistical significance was fixed at 0.05. SPSS version 19 was used for the statistical analyses.

Results

Characteristics of the Study Population

Socio-economic characteristics of households are presented in Table 1. Data were available for 7295 women at reproductive age living in 7341 households. Approximately (14 %) of households were headed by a female. Slightly less than half (43 %) of the heads of households had at least a primary school education compared to more than half of them (57 %) without any education. Furthermore,

Table 1 Socio-demographic characteristics of sub-nationally household sample survey 2008–2009

Variable	Frequency	Percentage
Household head education		
Education	3117	42.7
No education	4166	57.1
Missing	12	0.2
Household head sex		
Male	6264	85.9
Female	1010	13.8
Missing	21	0.3
Household head marital status		
Married	7057	96.7
Divorced	81	1.1
Widow	145	2.0
Missing	12	0.2
House type		
Separate	6256	85.8
Shared	1028	14.1
Missing	11	0.2
The outer wall material		
Concrete	6579	90.2
Wood/metal	695	9.5
Other	10	0.1
Missing	11	0.2
Household ownership of agriculture land		
Yes	3648	50
No	3636	49.8
Missing	11	0.2
Household having vehicle		
Automobile (care/bus/truck)	828	11.4
Farm wagon	40	0.5
Motor cycle	532	7.3
Other	83	1.1
Household ownership of livestock		
Yes	4458	61.1
No	2826	38.7
Missing	11	.2
Main source of drinking water for the family		
A piped water supply at home	2954	40.5
Water tank within the house filled from out side	609	8.3
Well inside the house	68	0.9
Well out side the house	2807	38.5
Surface water as a little river or lake	627	8.6
Others	219	3.0
Lightening source		
Electricity	3175	43.5
Gas	217	3.0
Kerosene	3874	53.1

Table 1 continued

Variable	Frequency	Percentage
Others	18	0.2
Toilet type		
Toilet connected to the public drain waste system	117	1.6
Old tradition latrine toilet connected to privet digging a ground hole	2906	39.8
Old tradition latrine toilet not connected to privet digging a ground hole	2077	28.5
Nothing available and the do open defection	2184	29.9
Under age married		
Yes	3512	48.3
No	3739	51.3
Missing	44	0.6
Family marriage		
Yes	1976	27.1
No	5275	72.3
Missing	44	0.6
Women genital mutilation or circumcised		
Yes	3405	46.7
No	3846	52.7
Missing	44	0.6
Women used tobacco		
Yes	1552	22.3
No	5699	78.1
Missing	44	0.6
Women chowing Qat		
Yes	2955	40.5
No	4296	58.9
Missing	44	0.6
Family planning		
Yes	2248	30.8
No	4629	63.5
Missing	418	5.7
Antenatal care		
Yes	3502	48
No	3372	46.6
Missing	421	5.8
Skilled birth attendance		
Yes	3329	45.6
No	3227	44.2
Missing	739	10.1
Total Households	7295	100

48 % of the women had under age marriage (i.e. marriage under 18 years old); 27 % family marriage (i.e. a marriage with man who is related as second cousin or closer); 22 % had used tobacco; 41 % had chewing qat; 31 % had family planning; and 48 % had antenatal care.

Construction of the SES Indices

The initial correlations between each of the SES indicators before the PCA are summarized in "Appendix 2". Overall, the correlation coefficients between the indicators ranged from low to moderate, with the highest correlation seen between drinking water source and water colleting time ($r = 0.70$) and lowest between land ownership and household head education ($r = 0.013$).

In the PCA, three components were extracted, which in total explained 54 % of the variance in household's SES. The first component had meaningful loadings (i.e., loadings greater than 0.40) for household water source, lightning type, sanitation, and fetching water time; therefore it was labeled 'housing quality index'. The second component was loaded by household land ownership, animal ownership, and vehicle ownership, and was labeled 'wealth index'. The last component was loaded by paternal education and outer wall material, hence was labeled 'educational index' ("Appendix 3").

Distribution of Population Characteristics by Study Outcomes

Maternal mortality was 0.3 % in the study population; spontaneous abortion was 25.1 %; stillbirth 8.3 %; neonatal mortality 1.0 %; and infant mortality 1.9 % (Table 2).

About 0.6 % of the poor households experienced maternal mortality; 0.1 % of the middle advantaged households experienced maternal mortality; and it was 0.3 % of the rich households. The corresponding figures for the spontaneous abortion were 29.4, 23.2 and 24.0 %, respectively; for stillbirths they were 12.4, 6.9, and 6.9 %, respectively; for neonatal deaths they were 1.7, 1.0 and 0.5 % %, respectively; and for infant mortality they were 3.5, 1.5, and 1.1 %, respectively (Table 2).

The five maternal and child health outcomes decrease steadily with the higher levels of the three socioeconomic indices. At the same time, almost all maternal and child health outcomes increased among women who had under age marriage, family marriage; tobacco usage; and chewing qat compared to women who did not engage in these behaviours (Table 2).

Associations Between SES Indices and Maternal and Child Health Outcomes

The associations between SES and maternal and child health outcomes are summarized in Table 3 and 4. None of the SES indices showed a strong association with maternal mortality (Table 3). Higher tertiles of the wealth, educational, and household housing quality indices were each associated with a decreased risk of spontaneous abortion

Table 2 Distribution of indicators of maternal and child health by SES indices and study population characteristics in rural Yemen, 2008–2009 sub-national household sample survey

Variable	Total*	Maternal death ($n = 20$) n (%)	Abortions ($n = 1823$) n (%)	Stillbirth ($n = 602$) n (%)	Neonatal death ($n = 74$) n (%)	Infant death ($n = 136$) n (%)
Wealth index						
1st tertile (lowest)	1805	10 (0.6)	530 (29.4)	224 (12.4)	30 (1.7)	63 (3.5)
2nd tertile	2953	2 (0.1)	686 (23.2)	205 (6.9)	31 (1.0)	44 (1.5)
3rd tertile (highest)	2525	8 (0.3)	607 (24.0)	173 (6.9)	13 (0.5)	29 (1.1)
Educational index						
1st tertile (lowest)	2498	10 (0.4)	668 (26.7)	256 (10.2)	47 (1.9)	77 (3.1)
2nd tertile	2366	5 (0.2)	595 (25.1)	154 (6.5)	16 (0.7)	35 (1.5)
3rd tertile (highest)	2419	5 (0.2)	560 (23.2)	192 (7.9)	11 (0.5)	24 (1.0)
Housing quality index						
1st tertile (lowest)	2441	12 (0.5)	713 (29.2)	160 (6.6)	25 (1.0)	53 (2.2)
2nd tertile	2432	3 (0.1)	603 (24.8)	215 (8.8)	29 (1.2)	49 (2.0)
3rd tertile (highest)	2410	5 (0.2)	507 (21.0)	227 (9.4)	20 (0.8)	34 (1.4)
Household head sex						
Male	6271	17 (0.3)	1637 (26.1)	548 (8.7)	70 (1.1)	129 (2.1)
Female	1010	3 (0.3)	186 (18.4)	54 (5.3)	4 (0.4)	7 (0.7)
Marital status						
Married	7057	20 (0.3)	1765 (25.0)	576 (8.2)	73 (1.0)	133 (1.9)
Divorced	81	0 (0.0)	16 (19.8)	8 (9.9)	0 (0.0)	2 (2.5)
Widow	145	0 (0.0)	42 (29.2)	18 (12.4)	1 (0.7)	1 (0.7)
Chewing Qat						
Yes	2957	14 (0.5)	1075 (36.4)	355 (12.0)	45 (1.5)	93 (3.1)
No	4296	6 (0.1)	748 (17.4)	247 (5.7)	29 (0.7)	43 (1.0)
Tobacco usage						
Yes	1556	7 (0.5)	563 (36.2)	263 (16.9)	30 (1.9)	63 (4.1)
No	5699	13 (0.2)	1260 (22.1)	339 (5.9)	44 (0.8)	73 (1.3)
Under age marriage						
Yes	3516	11 (0.3)	1235 (35.1)	351 (10.0)	48 (1.4)	96 (2.7)
No	3739	9 (0.2)	588 (15.7)	251 (6.7)	26 (0.7)	40 (1.1)
Family marriage						
Yes	1980	3 (0.2)	598 (30.2)	226 (11.4)	31 (1.6)	53 (2.7)
No	5275	17 (0.3)	1225 (23.2)	376 (7.1)	43 (0.8)	83 (1.6)
Provinces						
Ibb	2384	5 (0.2)	636 (26.7)	111 (4.7)	18 (0.8)	37 (1.6)
Taiz	2052	2 (0.1)	459 (22.4)	272 (13.3)	30 (1.5)	42 (2.0)
Hodeidah	1420	3 (0.2)	313 (22.0)	208 (14.6)	16 (1.1)	34 (2.4)
Al Dhale	1428	10 (0.7)	415 (29.1)	11 (0.8)	10 (0.7)	23 (1.6)

* May not sum to total as missing data are not presented

Table 3 Estimates of associations between household SES indices and maternal health outcomes: odds ratios [ORs and 95 % confidence intervals (95 % CIs)]

Variable	Maternal Death			Abortion		
	No. (%)	Unadjusted OR (95 % CI)	Adjusted OR (95 % CI)	No. (%)	Unadjusted OR (95 % CI)	Adjusted OR (95 % CI)
Wealth index						
Lowest tertile	10 (50.0)	1	1	530 (29.1)	1	1
2nd tertile	2 (10.0)	0.12 (0.03–0.56)	0.19 (0.04–0.92)	686 (37.6)	0.72 (0.63–0.83)	0.87 (0.75–1.01)
Highest tertile	8 (40.0)	0.57 (0.23–1.45)	0.92 (0.32–2.60)	607 (33.3)	0.76 (0.66–0.87)	0.82 (0.71–0.96)
P value		0.022	0.101		<0.001	0.047
Educational index						
Lowest tertile	10 (50.0)	1	1	668 (36.6)	1	1
2nd tertile	5 (25.0)	0.53 (0.180–1.547)	0.58 (0.19–1.75)	595 (32.6)	0.91 (0.80–1.04)	0.77 (0.66–0.89)
Highest tertile	5 (25.0)	0.516 (0.176–1.51)	0.59 (0.196–1.78)	560 (30.7)	0.82 (0.72–0.93)	0.73 (0.63–0.84)
P value		0.348	0.514		0.011	<0.001
Housing quality index						
Lowest tertile	12 (60.0)	1	1	713 (39.1)	1	1
2nd tertile	3 (15.0)	0.25 (0.70–0.89)	0.35 (0.10–1.30)	603 (33.1)	0.79 (0.70–0.90)	0.91 (0.79–1.05)
Highest tertile	5 (25.0)	0.42 (0.15–1.20)	0.48 (0.15–1.58)	507 (27.8)	0.64 (0.56–0.73)	0.70 (0.60–0.81)
P value		0.053	0.211		<0.001	<0.001

(Table 3). On the other hand, higher tertiles of wealth and educational indices were associated with a decreased risk of stillbirth (Table 4). In addition, higher tertiles of both wealth and educational indices were associated with decreased risks of infant and neonatal mortality (Table 4).

Discussion

By subjecting several individual and household level SES factors to factor analysis through PCA, we derived three distinct SES indices (wealth, educational and housing quality indices) to describe the SES of women from rural Yemen, which can be employed for research into maternal and child health. The initial correlations coefficients between each of the SES factors ranged from low to moderate (0.013–0.70), with the highest correlation seen between drinking water source and water colleting time. After adjusting for potential confounding factors, higher tertiles of each index were inversely associated with spontaneous abortion. Higher tertiles of wealth and educational indices were inversely associated with stillbirth, neonatal and infant mortality. However, none of the SES indices showed any strong association with maternal mortality.

Previous studies from low- and middle-income settings that have constructed indices to describe maternal SES primarily utilized individual level socioeconomic factors or employed indicators that measure only some components of SES or their proxies; hence, failed to consider household level socioeconomic factors [3, 6, 12–14]. It has been suggested that household level factors may better reflect and capture contextual influences on health [20, 21]. Such reality makes it crucial that in investigating the effect of SES on health, a more comprehensive approach that captures the diverse and multidimensional nature of SES should be employed. Specifically, considering that in most rural low-income settings, quantitative measures of the usually standard indicators of SES, such as education and income, are lacking, the use of household level material factors, such as ownership of farmland, cars, etc., become fundamental measures in generating women's SES indices [4, 12]. In the current study, given the lack of existing SES for research into maternal and child in rural Yemen, we employed an asset-based approach that incorporated individual and household level indicators to derive SES indices, categorized under the domains of wealth, educational, and housing quality, which we believe provide important benchmark for research into maternal and child health in rural Yemen. This approach is congruent with previous studies [3–5]. The low to moderate correlations found between single indicators in this study indicate that the usual practice of using single indicators or as proxies for others is inadequate [12]. As far as we are aware, this is the first effort of its kind in rural Yemen, hence presents a good opportunity for future research in these settings. The large sample and the random processes in sample selection

Table 4 Estimates of associations between household SES indices and child health outcomes: odds ratios [ORs and 95 % confidence intervals (95 % CIs)]

Variable	Stillbirth			Neonatal Death			Infant Death		
	No. (%)	Unadjusted OR (95 % CI)	Adjusted OR (95 % CI)	No. (%)	Unadjusted OR (95 % CI)	Adjusted OR (95 % CI)	No. (%)	Unadjusted OR (95 % CI)	Adjusted OR (95 % CI)
Wealth index									
Lowest tertile	224 (37.2)	1	1	29 (39.7)	1	1	63 (46.3)	1	1
2nd tertile	205 (34.1)	0.53 (0.42–0.67)	0.68 (0.53–0.88)	31 (42.5)	0.65 (0.39–0.56)	0.91 (0.53–1.56)	44 (32.4)	0.42 (0.28–0.62)	0.64 (0.40–1.01)
Highest tertile	173 (28.7)	0.56 (0.44–0.72)	0.72 (0.56–0.95)	13 (17.8)	0.32 (0.17–0.61)	0.43 (0.22–0.85)	29 (21.3)	0.32 (0.21–0.50)	0.46 (0.28–0.78)
P value		0.00	0.008		0.003	0.04		0.00	0.011
Educational index									
Lowest tertile	256 (42.5)	1	1	46 (63.0)	1	1	77 (56.6)	1	1
2nd tertile	154 (25.6)	0.57 (0.45–0.72)	0.50 (0.39–0.65)	16 (21.9)	0.36 (0.21–0.65)	0.43 (0.23–0.76)	35 (25.7)	0.47 (0.32–0.71)	0.41 (0.23–0.76)
Highest tertile	192 (31.9)	0.70 (0.56–0,88)	0.65 (0.51–0.83)	11 (15.1)	0.24 (0.13–0.47)	0.30 (0.15–0.58)	24 (17.6)	0.32 (0.20–0.50)	0.30 (0.15–0.69)
P value		<0.001	<0.001		<0.001	<0.001		<0.001	0.001
Housing quality index									
Lowest tertile	160 (26.6)	1	1	24 (32.9)	1	1	53 (59.0)	1	1
2nd tertile	215 (35.7)	0.81 (0.63–1.03)	1.06 (0.80–1.39)	29 (39.7)	1.21 (0.70–2.09)	1.24 (0.70–2.19)	49 (36.0)	0.93 (0.63–1.37)	0.84 (0.52–1.36)
Highest tertile	227 (37.7)	0.72 (0.56–0.92)	0.93 (0.71–1.57)	20 (27.4)	0.84 (0.47–1.53)	0.86 (0.46–1.62)	34 (25.0)	0.65 (0.42–1.0)	0.70 (0.42–1.16)
P value		0.29	0.57		0.46	0.45		0.12	0.38

provide the opportunity for generalizing our observations across different rural settings in Yemen.

This study does however have some limitations. Data on neonatal and infant mortality indicators were collected from women with reference to their latest childbirth during the two years preceding the survey, whereas data on maternal mortality was with reference to 5 years preceding the survey. Maternal recall of events 2–5 years prior to the survey may introduce some levels of recall bias to the estimates of association, although recall of previous mortality events within the timeframe of focus is less likely to be misinterpreted. Furthermore, the measured SES indices represented the conditions of the time of the interview, not of the time when the pregnancy outcomes were occurred. Given the cross-sectional design, we cannot infer any causality in the observed associations between the derived SES indices and indicators of maternal and child health outcomes.

The associations between each of the constructed SES indices and the maternal and child health outcomes somewhat varied. As has been previously acknowledged, these variations emphasize the fact that the associations between SES indices and health outcomes appear to be outcome-specific and that different SES measures may differentially impact health outcomes [10, 12, 22, 23]. We did not observe strong evidence on the association between the SES indices and maternal mortality. Some previous studies have however shown that mother's death during pregnancy or childbirth is more common among women from low SES and with low educational attainment than among those from higher SES or those having higher educational attainment [24, 25]. Our findings of no strong evidence of effect is however consistent with the report of Loudon who noted that maternal mortality appears not to be influenced by socio-economic factors, but may be influenced by standards of obstetric care [26]. Thus, elimination of preventable unpredictable life threatening complications during childbirth and the post-partum period through providing high-quality maternal care may eventually represent the key contributor to reduction in maternal mortality rather than mothers' SES. However, low coverage and poor quality of MCH services in Yemen especially in rural areas, where 53 % of mothers with live birth had not received any ANC visit and only 16 % of births occurring in health facilities, makes Yemeni women face a very high risk of maternal death regardless of their SES [17]. Furthermore, in most of rural Yemen, where 75 % of the population lives, health facilities performed only a few essential obstetric procedures and they are not able to perform some procedures as assisted vaginal delivery, cesarean deliveries and/or bold transfusion due to shortage of trained staff, equipment, and supplies [17].

Wealth, educational, and housing quality indices were each associated with spontaneous abortion, which is in accordance with findings from pervious studies [27–29]. The consistent finding reveal that women who are economically disadvantaged or those who have low educational level may experience higher rates of spontaneous abortion than women with better economic or educational status. In addition, socioeconomically disadvantage women are prone to experience heavy housework or physical work, such as collecting water and fire wood as in most rural Yemen, thus they appear to have experienced higher rates of abortion [28, 29]. The relationship between SES and spontaneous abortion however appear to vary across countries and contexts [30, 31].

Moreover, the results show that lower tertiles of wealth and educational indices, but not housing quality, were associated with stillbirth, which are in accordance with pervious studies showing that low SES is associated with an increased risk of stillbirth [32, 33], although contrary evidence also exists [34]. The increase in abortion and stillbirth among disadvantage women may likely reflect limited access and unhealthy seeking behavior of these women. However, given the inconsistent findings across studies, more comprehensive information in further studies on maternal health services accessibility and use patterns will allow us to more clearly examine the possible impact of these on stillbirth and abortion rates for specific socioeconomic women groups.

Women at higher levels of wealth and educational SES indices were also less likely to experience neonatal and infant deaths, but the housing quality index did not shown any strong association. The findings with wealth and educational SES indices in relation to neonatal death are consistent with some previous studies reporting that the risk of neonatal death was mostly concentrated amongst women with lower level of education [35–37] and those from poorer households [35, 38]. Similarly, the associations between wealth and educational SES indices and the risk of infant death agree with previous studies demonstrating more likelihood of infant death among lower SES households [39–42], although some studies have also reported no strong associations between measures of maternal illiteracy and infant death [41, 43, 44]. These differences in findings may imply that the relation between SES measures and infant mortality may be context-specific. Although our results indicate that neonatal and infant deaths appeared not to be strongly influenced by housing quality index, some previous studies have shown that water supply, and availability of sanitary facilities and electricity are strong predictors of child mortality [39, 45–47]. These findings may reflect the poor quality and unsustainable access to water, sanitation,

and electricity services. Though, the absence of proper drainage of household wastewater would create an infectious environment, which could help spread infectious diseases in both the mother and the newborn (48). Since, the purpose of this study was not to examine the different ways through which the source of water, sanitation, and electricity could affect the chances of neonatal and infant mortality, further study is needed on that.

Overall, the current study has demonstrated that within rural Yemeni settings, indicators of SES are important determinants of the population health, particularly the health of mothers and children. However, in order to comprehensively appreciate the putative impact of SES on the health of these populations, it is paramount for the development of indices for the measurement of SES in these rural populations, which unlike in developed nations, are less quantifiable using classic measures such as education and occupation, but hidden within the household measures. The findings from this study therefore shows that taking into account such household level factors, there are opportunities to uncover and construct SES indices that will advance health research on the real impact of SES on the health of rural women and children. These opportunities can then be translated into current health care policies aimed at meeting many of the health care needs of the socioeconomically disadvantaged women, children and families in rural Yemen.

Although the observed associations between the SES indices and maternal and child health outcomes may not imply causation, the findings have a number of policy implications for decision makers in rural Yemen. One is that this study clearly identifies women at the lower income and educational population strata to be in greater need of well-streamlined health services and behavior change interventions that will improve maternal and child health outcomes in these settings. In achieving this, it is crucial that both individual and population-based strategies are adapted, including prenatal and/or postpartum home visits or early parent training. There is also need to develop core population-based public health programs that integrate culturally appropriate services. These strategies should also target addressing emergency during pregnancy and delivery and should encourage poor and deprived women to use prenatal care and health facilities delivery services. Second, an indirect policy implication from this study is that there is need to invest more efforts in developing effective strategies that would enhance women's autonomy, both at the household and community levels, through providing targeted education for women, working relevant stakeholders to ensure more gender equity in wealth distribution. Such policy directions should take a life course approach that begins before conception or early in pregnancy up to adulthood.

Conclusion

By subjecting a number of household attributes to factor analysis the current study has developed three core SES indices, which we believe are a good benchmark for future research in maternal and child health in rural Yemen. The associations between the constructed SES indices and indicators of maternal and child health show that the SES indices are reliable predictors of maternal and child health outcomes in these settings. These findings therefore add to the growing body of evidence that SES is a multidimensional measure, so that for rural settings, examining both individual and household level SES indicators will provide a better means for evaluating the influences of SES on maternal and child health in these settings. This approach will help to develop appropriate policies that will mitigate the negative influences of SES on maternal and child health outcomes.

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Authors' Contribution This article was designed, analyzed and written by Alosaimi Abdullah under the supervision of Riitta Luoto and Bright Nwaru. Alserouri Abdelwahed, and Halima Mouniri did the surveys in the provinces. All authors commented and approved the final version of the manuscript.

Appendix 1

See Table 5.

Table 5 Operational definition and categorization of variables used for constructing the SES indices

Variables	Description
House type	Whether the house is separate = [2] or Sharing house = [1]
House outer wall material	Whether the outer wall material made of concrete or stones = [3], wood or metal = [2], other = [1].
Household ownership of vehicle	Whether the Household own automobile (care/bus/truck) = [3], farm wagon = [2], motorcycle or other = [1].
Household ownership of agriculture land	Whether the household has agriculture land – No (0); Yes [1].
Household ownership of livestock	Whether the household has own any domestic animal, goats, caws, poultry, hone bees, others – No (0); Yes [1].
Household head's education	Household head's education is defined based on the level of schooling and divided into two categories – *Illiterate* (0) = 0 years of schooling a or writing and reading without attending school, *literate* [1] = Primary 1–6 years of schooling or secondary
	6–12 years of schooling or post-secondary schooling for more than 12 years.
The main source of drinking water for the family	Drinking water source defined based on the accessible source type and divided into 5 types: [5] = accessible piped water within the premises of the house, [4] = a water tank within the house filled from outside, [3] = Well inside the house, [2] = Well outside the house, [1] = Surface water as a little river or lake *or* other.
Lightening source	Lightening source is divided into 4 categories – Electricity [4]; Gas [3]; Kerosene [2]; Others [1].
Water fetching time	Water fetching time is divided into 4 categories—0 time [5]; >0–15 min [3]; 16–30 [2]; >30 min [1].
Toilet type	Toilet type is divided into 4 categories—toilet connected to the public the public drain waste system [3]; old tradition latrine toilet connected to privet digging a ground Hole [2]; old tradition latrine toilet not connected to privet digging a ground Hole [1]; nothing available and the do open defection (0).

Appendix 2

See Table 6.

Table 6 Correlations between the variables used in the factor analysis for constructing the SES indices: Pearson correlation coefficients and their significant levels are presented

	Water fetching time	Household head's education	Toilet type	Main source of drinking water	Lightening source	Household ownership of livestock	Household ownership of agriculture land	House outer wall material	House type	Household ownership of vehicle
Water fetching time	1	0.01	0.33**	0.70**	0.38**	0.08**	0.17**	0.12**	0.08	0.13**
Household head's education	0.01	1	0.09**	0.01	0.10**	0.08**	0.00	0.07**	0.03	0.03
Toilet type	0.33**	0.09**	1	0.33**	0.40**	0.11**	0.07**	0.27**	0.00	0.15**
Main source of drinking water	0.70**	0.01	0.33**	1	0.41**	0.10**	0.20**	0.11**	0.09**	0.12**
Lightening source	0.38**	0.10**	0.40**	0.41**	1	0.07**	0.01	0.14**	0.03	0.13**
Household ownership of livestock	0.08**	0.08**	0.11**	0.10**	0.07**	1	0.46**	0.02	0.02	0.10**
Household ownership of agriculture land	0.17**	0.00	0.07**	0.20**	0.01	0.46**	1	0.09**	0.02	0.12**
House outer wall material	0.12**	0.07**	0.27**	0.11**	0.14**	0.02	0.09**	1	0.07**	0.04**
House type	0.08**	0.03	0.00	0.09**	0.03	0.02	0.02	0.07**	1	0.08**
Household ownership of vehicle	0.13**	0.03	0.15**	0.12**	0.13**	0.10**	0.12**	0.04**	0.08**	1

**$P < 0.001$

Appendix 3

See Table 7.

Table 7 PCA results showing the three extracted components, their loaded variables, their eigenvalues and the percentage of variance in SES explained by each component

Components	Variables loading on each component	Eigenvalues of each component	Percentage of variance explained by the component
Component 1: 'housing index'	Household water source, lightning type, sanitation, and fetching water time	2.56	25.6
Component 2: 'Wealth index'	Household land ownership, animal ownership, and vehicle ownership	1.52	15.2
Component 3: 'Educational index'	Paternal education and outer wall material	1.37	13.7
Total variance of SES explained by all components	_	_	54.5

House type has been excluded from variables loading on the extracted components as it has loading value $< \pm 0.40$

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