Nutritional Status and its Related Factors in Khalwa Residents, Khartoum state, Sudan.

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Abstract

Introduction

Khalwa is an Islamic educational institution, known as such in Sudan and called elsewhere Koranic institution. Our research aimed to assess the nutritional status and its related factors among Khalwa residents in Khartoum State.

Methods

A facility-based cross-sectional study was implemented in two localities of Khartoum State. A multistage sampling technique was used to selected 1273 residents. At first level, four khalwa were selected in the seven localities of Khartoum State through a stratified random sampling technique. At second level, in each of the khalwa selected, all the residents fulfilling the inclusion and exclusion criteria were included in the study. The collected data were firstly summarized numerically and graphically. Then, associations/differences among variables were determined through chi-square tests and ANOVA. A multinomial logistic regression established the relationship between the nutritional status of the residents and its related factors. All statistical tests were considered statistically significant when $p < 0.05$.

Results

The age of 1273 residents varied from 6 to 60 years with an average age of 15 years. Their mean body mass index (BMI) of 16.6 ± 3.4 ranged from 7.8 to 34.0. 73.8% (939/1272) of the residents were undernourished, 23.9% (309/1272) were well nourished and 2.3% (29/1272) were overweight/obese. The statistically significant factors related to the nutritional status of the residents were age (under-nourished $p=0.000$; well-nourished $p=0.004$), status in the khalwa ($p=0.001$ vs $p=0.075$), resting time ($p=0.002$ vs $p=0.038$), practices of hand washing ($p=0.165$ vs $p=0.011$) and exercising ($p=0.032$ vs $p=0.027$). The food practices, despite their contributions to the model, were not statistically significant ($p > 0.05$).

Discussion

The nutritional status of khalwa should be translated urgently in a community-directed intervention based on a partnership involving the affected communities, political and administrative authorities, national, bilateral and international donors to overcome the burden of malnutrition.

Keywords: Almajiri, Body mass index, Khalwa, Nutrition, Quranic, School.

73 Introduction

74 Malnutrition challenges the world with one in three people directly affected by underweight, vitamin
 75 and mineral deficiency, overweight, obesity and diet-related non-communicable diseases. These
 76 conditions increasingly coexist in a nation, community, household, or even in the same individual across
 77 the life course. While more than 1.9 billion adults were overweight or obese worldwide in 2015, 462
 78 million were underweight. In 2016, 155 million children < 5 years were affected by stunting while 41
 79 million were overweight and 52 million were affected by wasting. The Global Nutrition Report Group
 80 in targeting to end malnutrition by 2030 pointed out that at least 12 out of the 17 sustainable development
 81 goals (SDGs) contain indicators that are highly relevant to nutrition; it pointed out the central role of
 82 nutrition in sustainable development [1-3]. Accurate planning and implementation of intervention
 83 programmes for reducing morbidity and mortality related to under nutrition is crucial for assessment of
 84 community nutritional status. WHO Global Database on Child Growth and Malnutrition recommended
 85 the use of anthropometric measurements as biomarkers to reflect the overall nutritional status of a human
 86 being and to classify the spectrum of different nutritional problems [4,5]. Over 40 % of the global
 87 population suffer from water scarcity and at least 663 million people worldwide lack access to safe
 88 drinking water. One third of the world population lack access to an improved sanitation leading to 13%
 89 practicing open defecation; only 19% of people worldwide wash their hands after potential contact with
 90 excreta. Sub-Saharan Africa and South Asia remain the regions of the world with the lowest sanitation
 91 coverage [6-8]. In 2010, according to the Human Rights Watch there was about 5 million children
 92 attending thousands of Quranic boarding schools across the globe [9]. The denomination of Quranic
 93 schools and attendees varies across continents and countries. In Bangladesh, India, Pakistan, Singapour,
 94 and Somalia, the Quranic schools are named madrasah/madarassa, called tsangaya in Nigeria, Daaras in
 95 Mauritania and Senegal; in Egypt the koranic schools are known as alkitab, they are commonly named
 96 khalwa in Sudan [10-14]. Khalwa is a historical Islamic educational institution in Sudan, which despite
 97 its contribution to the Islamic education has experienced little change over the years [10,11]. It mostly
 98 depends on Islamic endowments, individual donations and charities; the quality of life of the residents
 99 is impacted by poor environmental and sanitation conditions associated to an unsatisfactory diet. It
 100 remains the main center of educational opportunity for many remote rural Sudanese people [15, 16].

101 Various researchers were interested in the nutritional status in institutions because of its direct health
 102 impact, particularly in Quranic schools. A descriptive cross-sectional study assessed the socioeconomic,
 103 demographic and health problems on a sample of 377 Almajri of Sokoto State in Northern Nigeria. The
 104 authors reported that 68.4% of the study participants belonged to poor socio economic families, 62.8%
 105 came from polygamous families, 59.7% had urinary tract infection and 17.8% suffered from skin disease.
 106 60.4% took bath once a month and 66.7% did not practice tooth brushing [17]. In the same country, a
 107 cross-sectional study on a sample of 360 almajiri evaluated the nutritional status and prevalence of

108 intestinal schistosomiasis in Kawo District, Kaduna Metropolis. The results pointed out that severe
109 malnutrition (body mass index < 15.3) prevailed more in infected children (n=67) than in non-infected
110 (n=293) with a prevalence of respectively 75.0% and 67.0%. These findings were recently confirmed
111 by Mohamed A et al. in East Nile locality, Sudan when assessing health and biosocial aspects of children
112 of Quranic schools. Their results revealed that students harboring schistosomiasis and 34.5% of the
113 students suffered from stunted growth while 17.0% were malnourished [18,19]. Further health problems
114 in Quranic schools were reported through a comparative cross-sectional study on a sample of 213
115 Almajiris and 200 public school pupils seeking to evaluate the prevalence and correlates of psychiatric
116 disorders. The study revealed a mean number of traumatic events significantly higher (1.38 ± 1.05)
117 among Almajiris compared to public school pupils (0.87 ± 0.83) with $p\text{-value} < 0.001$. Depression,
118 enuresis, substance use remained significantly higher among Almajiris; while separation anxiety was
119 significantly experienced by public school children [20].

120 Nutritional status is multifactorial involving both nutritional, biological, environmental, psychological
121 and physical factors. A descriptive cross-sectional study on a sample of 384 students of four primary
122 education institutions (Khalwa) assessed water and environmental sanitation services of primary
123 education at East Nile locality (Khartoum, Sudan). The findings revealed that 75% of the Khalwa had
124 just two meals/day, regarding the main source of safe drinking water, wells remained the first source of
125 water for 50% of the Khalwa (n=4). For waste management half of the Khalwa did not have containers
126 for storing solid waste which was consequently burned. Despite, 96.4% of the students were educated
127 solely in Khalwa, only 2/3 (67.2%) of them knew about the importance of personal hygiene [21]. An
128 analytical cross-sectional study carried out in Gezira State, Sudan on a sample of 180 students of Quranic
129 school, revealed a prevalence of anemia of 88.33%, The prevalence was higher (47.11%) in children
130 aged 11-14 years than in those of 7-10 years (38.15%) and 15-18 years (3.07%). The majority of the
131 study participants had iron deficiency anemia, followed by haemolytic, macrocytic and sickle cell
132 anemia [22]. Kheir.A.E.M. et al., in a cross-sectional survey on a sample of 406 males residing in a
133 traditional Quranic school, revealed a prevalence of night blindness of 24.0%, conjunctival xerosis was
134 12.5%; and Bitot's spots was 1.0%. A statistically significant association ($p=0.023$) was found between
135 the duration of stay (cut-off of 6 months continuously) at the institute and the development of night
136 blindness [23].

137 Khalwa, a dedicating place for teaching and memorization Quran and hadith, is a close environment
138 where live students, teachers, supervisors under the overall responsibility of al faki or sheikh. Our
139 research aimed to assess the nutritional status of the residents and its associated factors in four Khalwa,
140 distributed in two of the seven localities of Khartoum State, Sudan.

142 **Materials and Methods**

143 A facility-based cross-sectional study was implemented in two (Karari and Shareq Alneel) of the seven
144 localities of Khartoum State comprising an estimated total population of 7,993,851 people in 2018 per
145 Sudan Census Bureau of Statistics (<http://www.cbs.gov.sd/>). A multistage sampling technique was used
146 to select the study participants. At first level a stratified random sampling technique was used to select
147 the Khalwa proportionally to size of each locality based on the number of residents. At second level,
148 two Khalwa were randomly selected in each of the two localities included in the study. At third level,
149 in the selected Khalwa all the residents who fulfilled the inclusion and exclusion criteria (living in daily
150 basis in selected Khalwa) and who provided their well verbal informed consent were included in the
151 research.

152 The data were collected through a standardized interviewer-administrated tool, firstly developed in
153 English and translated in Arabic for easy understanding by the study participants. The questionnaire was
154 pre-tested prior to the study implementation in Al Khartoum and Ombadda localities.

155 The questionnaire comprised two parts. Part ,1 related to the institution, enabled to collected data, from
156 each Khalwa through observations and interviews to gather statistics on residents, accommodation,
157 sources of water and energy as well as environmental hygiene and sanitation including waste
158 management. Part 2 recorded data related to the study participants through four subheadings the
159 sociodemographic characteristics of the participants, their mode of living, their nutritional practices and
160 their anthropometric measures (height, weight and Body mass index). The anthropometric measures
161 weight (kg) and height (cm) were recorded for all the residents in using Floor type weight scale (model
162 Zt-120). The weight and height were measured in having each resident in minimum clothes, without
163 shoes and having each the head upright and looking straight forward. A relational database was
164 developed through EPI-Info™ 7.1.5.2 2 for easy data entry, to avoid duplication and to minimize data
165 entry errors in the two parts of questionnaire linked through a unique code created based of the Khalwa
166 code and the participant identification number.

167 The statistical package for social sciences (SPSS version 23) was used to summarize the data
168 numerically (mean, standard deviation, median) and graphically (frequency tables and graphics). Chi-
169 square tests were used to determine association between categorical variables; analysis of variance
170 determined the statistical association between continuous and categorical variables. A multinomial
171 logistic regression was performed to establish the relationship between the nutritional status of the
172 residents and a set of explanatory variables including age, status, duration of living in khalwa, resting
173 time, physical activities and nutritional practices of the residents. All statistical tests were considered as
174 statistically significant when $p < 0.05$.

Results

Profile of the Khalwa Surveyed in Karari and Shareq Alneel Localities

In the overall, the four Khalwa reported at the time of the research a total of 2726 residents with an average of 54 students per trainers (teachers and supervisors). With an average of 35 residents per bedroom and 5 residents per bed, the Khalwa were crowded. General network (75%, 3/4) was the first source of water which was stored in containers and traditional coolers in all the Khalwa. Uncovered zeer without tape (2 Khalwa/4) and basin (2/4) were used in half of the Khalwa whereas the recommended water storage, covered drums zeer with tap was found in one Khalwa only. Half of the Khalwa was connected to the general network as primary source of energy, half relied on generators and solar energy was the main source of energy in one institution.

A total of 88 latrines were recorded in the four Khalwa out of which 81 were in use which represented 92.0% (81/88) in term of availability of this commodity. The average number of residents per latrine used was 34 residents; this average ranged from 20 to 26 residents/latrine in Shareq Alneel locality to 103 to 207 residents/latrine in Karari locality. In the overall, an average of 32 residents shared a bathroom, this average varied from 20 to 26 residents/bathroom in Shareq Alneel to 74 to 155 residents/bathroom in Karari. For waste management, open burned system was used by 75.0% (3/4) of the Khalwa, this system was combined with car waste collection system by two, all located in Shareq Alneel locality (table 1).

Characteristics of the Residents

A total of 1273 residents was included in our survey. The age of the residents varied from 6 to 60 years with a median age of 15 years. They lived in their respective Khalwa for an average of 1 year ranging from 0 to 35 years; 59.7% (760/1273) were in their Khalwa for 1 to 4 years. The majority of the residents were students (94.4%, 1201/1273) and the remaining 5.6% (72/1273) were either teachers or supervisors. The mean duration of living in the Khalwa of 8.3 years $\pm$ 8.2 was higher for supervisors than teachers (6.3 years $\pm$ 6.9) and students (1.3 years $\pm$ 1.3) and this difference was statistically significant ($p=0.000$). The association between age of the residents and the years of living in Khalwa was also statistically significant ($p=0.000$).

203 **Table 1: Commodities and waste management system available in the four Khalwa of Karari and Shareq Alneel localities**

Commodities	Karari		Shareq Alneel		Total	% available ^d
	Mohamed Alhabib /Mojamah Zo	Almanara / Osman Ibn Afaan	Khalifa Mohamed Zein Alabdin	Maseed Elsheikh ALobeid Wd B		
Type of latrines						
Improved Pit latrine	.	1	1	1	3	75.0
Pit latrine	1				1	25.0
Open defecation	1				1	25.0
Use of latrines						
Total number of Latrines	4	5	49	30	88	
Latrines in use	3	5	49	24	81	92.0
Average residents/Latrine used ^a	207	103	20	26	34	
Use of bathrooms						
Total number of bathrooms	4	7	49	30	90	
Number of bathrooms in use	4	7	49	24	84	93.3
Average residents/bathroom used ^b	155	74	20	26	32	
Waste Management						
Open burned system	1		1	1	3	75.0
Waste car collection system	.		1	1	2	50.0
Residents ^c	620	516	963	627	2726	

204 a: computed as number of residents per khalwa/number of latrines used. b: number of residents per khalwa/number of bathroom used. c: total number of residents (teachers+supervisors+students) as reported
205 at the time of the survey. d: Percentage calculated as total number of commodities reported/4 Khalwa x 100, or as the number of commodities used/total number of commodities x 100.

Mode of living of the study participants

Resting time of the residents

The resting time (in hour) of the residents were estimated by subtracting the time of waking up from the one of going to bed. The resting time of the residents ranged from 5 to 8 hours with an average of 6.7 hours $\pm$ 0.7. This average differed from one Khalwa to another, it was lower (6.3 hours) in Almanara/Karari and Khalifa Mohamed Zein Alabdin/Shareq Alneel compared to Mohamed Alhabib/Karari and Maseed Elsheikh/Shareq Alneel where the residents had 7 hours of sleep. According to the age of the residents, the resting time was lower in the younger age groups: 6.4 hours $\pm$ 0.6 (< 15 years) and 6.9 hours $\pm$ 0.6 (15-24 years). In the age groups $\geq$ 25 years it ranged from 7.1 $\pm$ 0.8 ($\geq$ 35 years) to 7.2 $\pm$ 0.6 (25-34 years). The resting time of the students of 6.6 hours $\pm$ 0.6 was lower than of the teachers (7.0 hours $\pm$ 0.8) and supervisors (7.1 hours $\pm$ 0.8). A statistically significant difference was found between resting time and institutions ($p=0.000$), age groups ($p=0.000$) and status of the residents ($p=0.000$).

Activities of the residents

The residents of the Khalwa performed five main activities namely reading and writing Quran, walking, cooking, cleaning their respective Khalwa and washing their clothes. *Reading and writing Quran* was the predominant activity (100.0%, 1273/1273) in all the Khalwa. According to the Khalwa, *walking* is performed daily by 95.9% (1212/1273) of the residents, daily *cooking* by 59.6% (716/1202) whereas, cooking was an occasional activity for 40.3% (485/1202). *Cleaning their respective Khalwa* was an activity implemented once a week by 78.2% (995/1273) of the residents and 94.5% (1203/1273) of the participants *washed their clothes* once a week. According to the status of the residents, walking was practiced by all the teachers (n=36), supervisors (n=36) and students (n=1201). The cooking activity was performed mainly by the students (100.0%, 1201/1201) who carried the activity on a daily basis (59.6%, 716/1201) and occasionally (40.4%, 485/1201). All the three bodies participated in cleaning their Khalwa, mainly the students (91.0%, 1093/1201) followed by the supervisors (38.9%, 14/36) and the teachers (22.2%, 8/36).

Hygiene and Sanitation

Of the 1273 participants, 67.6% (861/1273) practiced hand washing without soap, 31.0% (394/1273) with soap, 0.8% (10/1273) reported washing hands with sand and 0.6% (8/1273) did not practice hand washing. The practice of hand washing was regrouped as “good practice” when participants washed hands with soap and all other three practices of hand washing was labeled as “poor practice”. In the

overall, 69.0% (879/1273) of the residents had poor practice of hand washing and the remaining 31.0% (394/1273) had good practice. A statistically significant difference was found between the practice of hand washing across Khalwa ($p=0.000$), status of the residents ($p=0.000$) and age of the participants ($p=0.000$). All the residents across the four Khalwa used “miswak” for teeth brushing before each prayer. 23.2% (294/1267) of participants brushed once a day their teeth with paste and the remaining 76.8% (973/1267) brushed their teeth without paste. Teeth brushing with paste was statistically different ($p=0.000$) across Khalwa and the status of residents. Student had the lowest prevalence of teeth brushing (19.7%, 235/1195) with paste.

Nutritional practices and intakes in the Khalwa

In general, the residents had two meals a day, breakfast at 10:00 am for 96.5% (1228/1273) and at 11:00 am for the remaining 3.5% (45/1273). The second meal (lunch) was served at 5:00 pm for the majority (99.5%, 1267/1273) and at 4:00 pm for 6 residents (0.5%). 32 (2.5%) residents had dinner at 10:00 pm. Of those having dinner, 52.8% were teachers, 27.8% supervisors and 0.2% students. Almost all the residents (96.6%, 1227/1270) reported that they needed extra meals; they were students (100.0%, 1119/1119), teachers (52.8%, 19/36) and supervisors (9/35).

Assida (sorghum seeds crushed and cooked) and served with *mullah* (water, scanty grinded dried meat and okra) was the food consumed on a daily basis in all the Khalwa by respectively 99.6% (1261/1266) and 99.7% (1263/1267) of the residents. *Saliga/fatta* (meat soup with bread) was served either occasionally (55.2%, 703/1273) or on a weekly basis (44.5%, 566/1273). *Beans* (for preparing tamia, fowl, balila, and loubia), were generally served occasionally (54.8%, 480/876) or every day (44.6%, 391/876). The frequency of consumption of bread was occasionally (95.1%, 523/550), daily (2.7%, 15/550) and weekly (12/550).

The consumption of fresh fruits was not a habit with 5 residents out of which 4 (3 teachers and 1 supervisor) had fruits weekly and a teacher daily. Dattes (dry fruits) were consumed occasionally (72.3%, 910/1258), daily (27.3%, 343/1258) and weekly (0.4%, 5/1258). Having dry fruits on a daily basis was more frequent in teacher population (42.9%, 15/35) than in supervisors (40.0%, 14/35) and students (26.4%, 314/1188).

Nashah (porridge made of cereals and sugar) was consumed by all (1273/1273) the residents on a weekly basis, *naturel juice* (hisbiscus, conceales) by 1.9% (24/1273) on a daily basis by 6 residents and occasionally by 18. 1.2% (15/1273) had *milk* every day (7 residents) and occasionally (8 residents). The majority (74.8%, 943/1261) of the residents had tea on a daily basis, 24.7% (312/1261) occasionally,

0.3% (4/1261) once a week and 0.2% (2/1261) never took tea. Coffee was reported to be drunk every day by 14.8% (67/454) of the residents and occasionally by 85.2% (387/454).

Anthropometric measurements

The median weight of the residents (n=1272) of 36 kg ranged from 11 to 107 kg. According to the Khalwa, the weight varied from 34.3 kg±13.7 to 43.0 kg±12.6. The students had a mean weight lower (37.6 kg ±12.7) than the teachers (60.1 kg±16.6) and the supervisors (62.6 kg±24.5). A statistically significant difference ($p=0.000$) was found between the weight and the status of the residents. With regard to the duration of living in Khalwa, the mean weight was lower (37.2 kg±13.0) for those residing for 1-4 years than those living for < 1 year (38.8 kg±13.2) and ≥ 5 years (61.2 kg±19.0). A statistically significant difference was found between the age of the participants, the duration of living in Khalwa and the weight with a p -value of respectively 0.000.

The 1272 residents had a height ranging from 1.1 m to 1.9 m with a median height of 1.5 meter. According to their respective Khalwa, the mean height of the residents (n=1272) of 1.5 m±0.2 varied between 1.4 m±0.1 and 1.5 m±0.2. The lowest mean height (1.5 m±0.2) was recorded in students. The mean height increased with the age of the residents and their respective length of living in their respective Khalwa. A statistically significant difference ($p=0.000$) was found between Khalwa, status of the residents, age of the study participants, length of living and height of the residents.

The mean body mass index (BMI) of the residents (n=1272) of 16.6±3.4 ranged from 7.8 to 34.0. This mean BMI varied across Khalwa, status and age of the residents with a statistically significant difference ($p=0.000$). The cutoff points proposed by the World Health Organization were used for classification of the nutritional status of the residents. The majority (73.8%, 939/1272) of the residents were underweight (BMI < 18.5 kg/m²), 23.9% (304/1272) had normal weight (BMI 18.5-24.9 kg/m²), 2.0% (25/1272) were overweight (BMI ≥ 25 kg/m²) and 0.3% (0.3%, 4/1272) were obese (BMI ≥ 25 kg/m²).

According to WHO classification, the BMI of the residents was regrouped in three categories namely undernourished (underweight), well nourished (those with normal weight) and overweight/obesity. 73.8% (939/1272) of the residents were undernourished, 23.9% (23.9%, 304/1272) were well nourished and 2.3% (29/1272) were overweight/obese. The prevalence of undernourished of 73.8% ranged from 65.9% in Karari Mohamed Alhabib to 86.2% in Shareq Alneel Khalifa Mohamed Zein Alabdin as revealed by [table 2](#) This average prevalence ranged from 30.6% (11/36) among the supervisors to 76.4% (917/1201) among the students. The prevalence of undernourished was higher 93.5% (589/630) in the age group < 15 years. According to the duration of living in Khalwa, the prevalence of undernourished was higher (76.8%, 584/760) in those living since 1-4 years in Khalwa compared to the residents living < 1 year (73.8%, 333/451) and ≥ 5 years (36.1%, 22/61).

Table 2: Nutritional status of the residents according to their Khalwa, status, age and duration of living in their respective institution (n=1273)

Variable	Nutritional status			Total	% under-nourished
	Undernourished	Well nourished	Overweight/Obesity		
Khalwa					
Shareq Alneel Khalifa Mohamed Zein Alabdin	193	23	8	224	86.2
Karari Almanara	346	86	10	442	78.3
Shareq Alneel Maseed Elsheikh	187	90	6	283	66.1
Karari Mohamed Alhabib	213	105	5	323	65.9
Total	939	304	29	1272	73.8
Status of the residents					
Teacher	11	15	9	35	31.4
Supervisor	11	12	13	36	30.6
Student	917	277	7	1201	76.4
Total	939	304	29	1272	73.8
Age group of the residents					
< 15 years	589	41	0	630	93.5
15-24 years	329	230	7	566	58.1
25-34 years	9	23	8	40	22.5
≥ 35 years	4	10	14	28	14.3
Total	931	304	29	1264	73.7
Duration of living in Khalwa					
< 1 year	333	115	3	451	73.8
1-4 years	584	168	8	760	76.8
≥ 5 years	22	21	18	61	36.1
Total	939	304	29	1272	73.8

Relationship between the nutritional status of the Khalwa residents and their nutritional practices and environmental factors

A multinomial logistic regression was performed to assess the relationship between nine explanatory variables and the nutritional status of the residents. This later was prevalent as under-nourished (73.8%, 939/1272), well-nourished (23.9%, 304/1272) and overweight/obesity (2.3%, 29/1272). The nine predictors used were namely the age of the residents in years, the duration of living in Khalwa in years, the status of the residents (teacher, supervisor, student), the resting time (sleep), hand washing (good and poor practice), exercising daily (yes=every day; no=once a week/occasionally), food intake measured as food2 (meals made of beans) and food4 (yes= having once a week Saliga/Fatta; no=occasionally/never) and dry fruit consumption (yes=having dattes every day; no=dattes served once a week/occasionally). The reference subpopulation for nutritional status used in the multinomial regression model was “overweight/obesity” which was compared with the subpopulations “under-nourished” and “well-nourished” for each of the predictive factors.

324 ***Under-nourished relative overweight/obesity***

325 Age ($p=0.000$), status of the residents ($p=0.0001$), resting time/sleep($p=0.002$) and exercising ($p=0.032$)
 326 were statistically associated to the nutritional status of the residents. Having daily dattes despite not
 327 statistically significant ($p=0.056$) contributed to explain the nutritional status of the residents by 4.4
 328 times [95% CI:0.965-20.316]. Eating salitiga/fatta weekly contributed to the nutritional status by 2.8
 329 times [OR=2.804, 95% CI:0.12-65.265] despite a no statistically significant association ($p=0.521$). Hand
 330 washing practice [OR= 0.369, 95% CI:0.09-1.508, $p=0.165$] with a coefficient of -0.996 indicated that
 331 the practice of hand washing was more in under-nourished resident students. Having meals made with
 332 beans [OR= 0.246, 95% CI:0.031-1.964, $p=0.186$] had a negative contribution to the model with a
 333 coefficient of -1.402 indicating eating meals processed with beans occasionally/every week led more
 334 likely to be undernourished (table 3).

335 ***Well-nourished relative overweight/obesity***

336 Age of the residents [OR=0.901, 95% CI:0.84-0.966, $p=0.004$], resting time [OR=0.315, 95% CI:0.105-
 337 0.94, $p=0.038$], practice of hand washing [OR=0.167, 95% CI:0.042-0.668, $p=0.011$],
 338 exercising/walking every day [OR=0.366, 95% CI:0.15-0.89, $p=0.027$] had all a statistically significant
 339 association with the nutritional status of the residents. The status of the residents contributing to the
 340 model by 2.13 times [95% CI:0.926-4.9, $p=0.075$] was not statistically associated to the nutritional status;
 341 as well as having daily dattes [95% CI:0.348-6.13, $p=0.604$] contributing by 1.5 times. The duration of
 342 living in Khalwa, the meals processed with beans or eating saliga/fatta, were not statistically significant
 343 but their negative contributions indicated that as the nutritional status (well-nourished) increased, those
 344 explanatory variables decreased (table 3).

345 In the overall, the nutritional status of the residents of the Khalwa surveyed were statistically associated
 346 with the age of the residents (under-nourished $p=0.000$; well-nourished $p=0.004$), the status of the
 347 residents statistically significant ($p=0.001$) in under-nourished was not statistically significant ($p=0.075$)
 348 in well-nourished subpopulation. The resting time was statistically associated with the nutritional status
 349 in both under-nourished and well-nourished with a p -value of respectively 0.002 and 0.038. The practice
 350 of hand washing not statistically associated with the nutritional status in under-nourished ($p=0.165$) was
 351 statistically associated with the nutritional status in well-nourished subpopulation ($p=0.011$) with a
 352 negative contribution in both subpopulations of respectively -0.996 and -1.787 indicating in both
 353 subpopulations when the nutritional status improved, the practice of hand washing decreased.

354 A statistical significant association between nutritional status and exercising in both subpopulations was
 355 found (exercising in under-nourished $p=0.032$ vs exercising in well-nourished $p=0.027$) with a

356 contribution to the model of respectively -1.045 and -1.006 indicating better the nutritional status, poor
357 was the practice of exercising.

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Table 3: Multinomial regression model predicting the nutritional status in Khalwa based on the age, status, duration of living in Khalwa, hygiene and dietary habits when using overweight/obesity as reference subpopulation.

Subpopulation	Variable	B	Std. Error	Wald	df	p	OR	95% CI OR	
								Lower	Upper
Under-nourished	Intercept	15.072	5.549	7.377	1	0.007			
	Age	-0.251	0.05	25.441	1	0.000	0.778	0.705	0.858
	Live	0.071	0.069	1.061	1	0.303	1.074	0.938	1.23
	Status	2.028	0.607	11.159	1	0.001	7.602	2.313	24.994
	Sleep	-1.786	0.581	9.467	1	0.002	0.168	0.054	0.523
	Hand washing practice	-0.996	0.718	1.926	1	0.165	0.369	0.09	1.508
	Exercising	-1.045	0.487	4.606	1	0.032	0.352	0.135	0.913
	Food2 (made with beans)	-1.402	1.06	1.75	1	0.186	0.246	0.031	1.964
	Food4 (Saliga/Fatta once a week)	1.031	1.606	0.412	1	0.521	2.804	0.12	65.265
	DryFruits1 (having dattes every day)	1.488	0.777	3.664	1	0.056	4.428	0.965	20.316
Well- nourished	Intercept	15.233	5.339	8.14	1	0.004			
	Age	-0.104	0.036	8.499	1	0.004	0.901	0.84	0.966
	Live	-0.051	0.056	0.848	1	0.357	0.95	0.852	1.059
	Status	0.756	0.425	3.168	1	0.075	2.13	0.926	4.9
	Sleep	-1.156	0.559	4.284	1	0.038	0.315	0.105	0.94
	Hand washing	-1.787	0.706	6.407	1	0.011	0.167	0.042	0.668
	Exercising	-1.006	0.454	4.913	1	0.027	0.366	0.15	0.89
	Food2 (made with beans)	-0.842	1.044	0.651	1	0.42	0.431	0.056	3.331
	Food4 (Saliga/Fatta once a week)	-0.393	1.512	0.068	1	0.795	0.675	0.035	13.074
	DryFruits1 (having dattes every day)	0.379	0.732	0.269	1	0.604	1.461	0.348	6.13

370 Discussion

371 In our study, the residents, all males (n=1273) with an average age of 15 years (range:6-60 years) were
 372 teachers (2.8%), supervisors (2.8%) and students (94.4%). This last population had an average age of
 373 14.6 years $\pm$ 3.8 (range:6-38 years). The residents had two meals/day with 96.6% in need of extra meals.
 374 This was in line with Mohamed et al. [21] who indicated that two meals were daily served in 75.0% of
 375 the khalwa surveyed and 25.0% had one meal per day. In other institutional settings, the numbers of
 376 meals served to secondary school students varied from two meals (10.5%) to more than three/daily
 377 (1.4%) with 88.1% having three meals/day [24]. Assida (99.6%) and mullah (99,7%) were the foods
 378 daily served to the residents whereas saliga/fatta, were served occasionally. Nutritional practices varied
 379 from cultures and societies. Kheir A.E.M. et al. [23] reported that in a Traditional Quran Boarding
 380 School in Sudan, boys diet consisted most of a staple cereal (sorghum or millet) and “mullah” (water,
 381 scanty, grinded dried meat and okra) whereas in Nigeria [25] 67.1% of the foods consumed were cereals;
 382 10.1% were roots and tubers consumption, legumes were 21.1%, vegetables 16.4%, milk and products
 383 3.1%, meat and fish 3.4% and fruits 4.1%.

384 Our study revealed that the resting time of the residents ranged from 5 to 8 hours with an average of 6.7
 385 hours $\pm$ 0.7. This average was lower (6.6 hours $\pm$ 0.6) in the group of students than in teachers (7.0
 386 hours $\pm$ 0.8) and supervisors (7.1 hours $\pm$ 0.8) with a statistically significant difference ($p=0.00$) between
 387 the status of the residents and their resting time. Musaiger.A.O. et al. [26] in their research on obesity,
 388 dietary habits, and sedentary behaviors among adolescents in Sudan reported that 28.0% (112/400) of
 389 the participants slept for < 7 hours/day and 72.0% (288/400) had $\geq$ 7 hours sleep. Our research did not
 390 focus on mental health which could impact the nutritional status of a community, however we took note
 391 of the findings of Abubakar-Abdullateef et al [13] who indicated in a comparative study on a sample of
 392 213 Almajiris and 200 public school pupils that the proportion of participants having any mental health
 393 problems among the Almajiri and public school pupils was 57.7% and 37% respectively.

394 Regarding the physical activities, 95.9% of our study participants reported walking daily, cooking was
 395 daily performed by 59.6% predominately by students; 94.5% of the participants washed their clothes
 396 once a week and 78.2% cleaned their institution once a week. In assessing the nutritional status of
 397 secondary school adolescents (13-18 years), Abdalla.M.M.A et al [24] reported that 73.8% of their study
 398 population (n=210) practiced physical activities and 26.2% did not. The frequency of the physical
 399 activities was daily (47.6%), two-three times/week (26.2%) and never (26.2%). The types of physical
 400 activities performed were predominately football (51.0%) followed up by swimming (19.0%), jogging
 401 (2.9%) and walking (1.0%).

402 Regarding hygiene and sanitation, 31.0% of our study population had a good practice of hand washing,
 403 23.2% of the residents brushed once a day their teeth with paste. The four Khalwa were crowded with

an average of 35 residents/bedroom and 5 residents/bed. Improved pit latrine was the most frequent types of latrine available (75.0%,3/4) and open burned system was used by 3 of the 4 Khalwa for waste management. In their study on water and environmental sanitation services available to primary education (Khalwa), Mohamed et al [21] revealed that 98.4% of the students practiced hand washing with not all of them using soap. The benefits of brushing teeth were not known by 9.4% and 90.6% recognized the religious prescription of teeth brushing. The mean BMI of the residents (n=1272) of 16.6±3.4 ranged from 7.8 to 34.0; it varied across Khalwa, status and age of the residents with a statistically significant difference ($p=0.000$) 73.8% of the residents were undernourished, 23.9% were well nourished and 2.3% were overweight/obese. In Sudan, various authors discussed the nutritional status in different institutions and across age groups. Faroug Bakheit Mohamed Ahmed et al. [27] found that 87.2% of children had normal nutrition status and the remaining 12.8% suffered from malnutrition whereas Musaiger.A.O. et al. [28] revealed that 20.5% the study population were underweight, 14.7% were overweight and 1.7 % were obese and Ali A. A.A et al. who used anthropometry as an indicator of nutritional status of Sudanese prepubertal school children (6-9 years) [29] found that underweight was 22.34% and obesity 2.13% with no marked gender variation. Mohamed A et al. who assessed the health and biosocial aspects of children at Quranic Schools indicated that 34.0% and 17.0% of the study participants were respectively underweight and malnourished [18]. Elsewhere in the literature, Mohammed M et al. [19] assessing the nutritional status and prevalence of intestinal schistosomiasis among Al-majiri population in Kawo District of Kaduna Metropolis (Nigeria) revealed that severe malnutrition prevailed more in infected children (75.0%) than in non-infected (67.0%). Ganganahalli P et al. [30] found in a sample of 176 children of a private school that 84.1% had normal body mass index, 10.2% were overweight and 5.7% were obese. Whereas in Iran, through a screening program to assess the health and nutritional status of 2596 school children, Rezaeian S et al. [31] revealed a prevalence of wasting of 3.1%, underweight of 9.48% and stunting of 2.85%.

The limitations related to our study were its restriction to the foods practices, the hygiene and sanitation conditions of the residents, their access to safe drinking water; in the other hand, the health conditions including mental status of the residents were not investigated. However, despite those limitations, the factors related to the nutritional status of the residents were assessed through a multinomial regression analysis which revealed that age of the residents (undernourished $p=0.000$; well-nourished $p=0.004$), their status (undernourished $p=0.001$; well-nourished $p=0.075$), their resting time (undernourished $p=0.002$ vs well-nourished $p=0.038$), their practice of handwashing (undernourished $p=0.165$ vs well-nourished $p=0.011$), and their physical activity (undernourished $p=0.032$ vs well-nourished $p=0.027$) were the statistically significant contributors related to the nutritional status of Khalwa residents. The food practices despite their contributions to the model were not statistically significant ($p > 0.05$).

439 **Conclusions**

440 Khalwa offers an opportunity of learning to low socio-economic children; furthermore, as an institution
 441 dedicating to memorizing the Quran, it was not surprising to found a high proportion of undernourished
 442 predominately in < 15 years in such close environment. This nutritional status of the residents of Khalwa
 443 should be translated urgently into proper actions to overcome the burden of malnutrition through a
 444 public-private partnership for implementing nutritional and water sanitation and hygiene (WASH)
 445 programmes alongside with education programmes.

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CONTRIBUTIONS OF THE AUTHORS

IHG: Designed and implemented the research, participated actively in the statistical analysis and read the initial drafts of the manuscript.

MIS: Computerized the data, participated actively in the statistical analysis and draft the manuscript.

AY& IAP: Assisted in data collection and coding.

MN: Approved the research proposal and guided the statistical analysis and participating in the proofreading.

MH: Participating in the proofreading/

All the authors read and approved the final version of the manuscript prior to its submission.

Data Availability

In accordance to data sharing and PLOS ONE policy on the matter, the authors declared that if the submitted manuscript is accepted for publication, the data will be deposited in the generalist repository of Dryad.

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CONFLICT OF INTEREST

No conflict of interest

ETHICAL CLEARANCE

The research proposal was approved by Sumasri Institutional Review Board in the framework of community based survey. Authorization for implementation of the research was obtained from each individual Sheik of the four Khalwa surveyed. A verbal well informed consent was also obtained from each of the residents included in the research. The confidentiality was insured through the use of an anonymous research tool. The participants were reassured that the data collected from them will not be used for any other purpose other the objectives assigned to the research.