ORIGINAL RESEARCH ARTICLE

Effect of mHealth Communication on Modifiable Risk Factors of Non-Communicable Diseases in An Adult Rural Population of District Gautam Buddha Nagar, Uttar Pradesh

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ABSTRACT

Introduction: Non-communicable diseases (NCDs) are responsible for 74% of all deaths globally. Burden of NCDs can be reduced by decreasing the modifiable risk factors associated with these diseases through behavioural change which can be done by the use of mHealth communication. **Objectives:** To assess the effect of mHealth communication on modifiable risk factors in an adult rural population of District Gautam Buddha Nagar, Uttar Pradesh.

Methodology: A Community-based Interventional study was conducted among 480 adult subjects in the rural area of District Gautam Buddha Nagar, Uttar Pradesh. Baseline information on sociodemographic variables, behavioural risk factors (STEP 1), anthropometric and physiological risk factors (STEP 2), and biochemical risk factors (STEP 3) of NCDs was collected. mHealth intervention in the form of telephone calls and text messages was carried out for reduction of NCD risk factors following which post-intervention data of the risk factors was collected.

Results: After mHealth intervention, significant reduction in tobacco use, alcohol use, unhealthy diet, physical inactivity, BMI, waist hip ratio, blood pressure, fasting blood sugar, total cholesterol, total triglyceride and low-density lipoproteins was observed in intervention group with respect to control group.

Conclusion: Effect of mHealth communication contributed significantly to decrease majority of the modifiable risk factors of NCDs.

Keywords: Non-Communicable Diseases, mHealth communication, Modifiable Risk factors, Rural population

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INTRODUCTION

Diseases which do not pass from person to person, persist for long and have a slow progression are known as Non-Communicable diseases (NCDs). The major NCDs are cardiovascular diseases, including stroke, hypertension and heart disease, cancer, chronic respiratory diseases including chronic obstructive pulmonary disease and asthma, and diabetes. The susceptibility to suffer from NCDs increases due to four major modifiable behavioural risk factors i.e. tobacco use, harmful use of alcohol, unhealthy diet and physical inactivity. These behavioural risk factors can lead to raised blood pressure, increased blood glucose, elevated blood lipids and obesity contributing to increased burden of NCDs.[1]

Globally, deaths due to NCDs have increased by 15% between 2010 and 2020 (to 44 million deaths) with an estimated 10.4 million deaths in South-East Asia.[2] There is also a sharp rise in the prevalence of NCDs in India as hypertension prevalence among men and women has increased from 15% and 11% in National Family Health Survey-4(NFHS-4) to 24% and 21% in NFHS-5 respectively. Similarly, proportion of men and women reporting random blood glucose >140 mg/dl has increased from 8% and 5.8% in NFHS-4 to 14% and 12% in NFHS-5 respectively.[3]

To reduce the burden of NCDs, main focus is on reducing the risk factors associated with these diseases through behaviour change which can be done by use of various modes of communications like newspaper, television, radio, mobile phones, internet etc.[4] In a developing country like India, telecom service providers are now investing in rural areas as well. Increase in the initiative for connecting people all across the areas either rural or urban has driven the development of mobile health (mHealth) system in the country. mHealth is cost-effective because of the utilization of wireless services.[5]

mHealth communications has been found to be useful in modifying the risk factors associated with NCDs. A review of 15 studies conducted in 13 developing countries emphasized the positive effect of mHealth communication in promoting physical activity and healthy diets.[6]

Therefore, this study was conducted with the rationale of evaluating the effect of mHealth communication in modifying the risk factors of NCDs in a rural population of District Gautam Buddha Nagar, Uttar Pradesh, India. Moreover, not many studies in India have been conducted to assess the role of mHealth communication in modifying the risk factors of NCDs.

METHODOLOGY

A Community-based Interventional study was conducted in the Rural Field Practice area of Department of Community Medicine of a medical college in District Gautam Buddha Nagar. The study was conducted from July 2019 to June 2022. The study included adults aged ≥ 18 years of age and residing in the selected study area for at least 6 months.

Eligibility criteria: Adults aged ≥ 18 years of age and residing in the selected study area for at least 6 months were included in the study. Subjects with impaired hearing, inability to talk or severe mental retardation were excluded from the study. Pregnant women and those who could not be contacted after 3 successive visits were also excluded.

Sample size: The sample size was calculated using the formula:

$$\text{Sample size} = \frac{2\,(Z_{\alpha} + Z_{1-\beta})^2 pq}{d^2}$$

Where, Z_{α} is type 1 error, $Z_{1-\beta}$ is power, $p = (p_1+p_2)/2$; p_1= proportion before intervention, p_2 = proportion after intervention, q is (1-p) and d is absolute difference expected after intervention.

According to a study done in 2013[7] in rural catchment area of Rural Health Training Centre (RHTC), Panchaytan the least prevalent modifiable risk factor was that of tobacco consumption (17%).

Thus, proportion before intervention $p_1 = 0.17$

Assuming that our intervention would lead to 50% reduction in the prevalence of risk factor. Therefore, proportion after intervention; $p_2 = 0.08$, the calculated sample size for each group was 218. Adding 10 % for attrition, the final sample size for each group was 240.

Sampling Technique: The study was conducted in the rural catchment area of Rural Health Training Centre (RHTC) under the Department of Community Medicine of the institute which caters to six villages. These six villages in the study area were randomly allocated into two groups, namely intervention and control. A total of 240 households were selected randomly from each group according to Population Proportion Sampling method (PPS). The households from each village were selected randomly using the households list available at Rural Health Training Centre. The selected households were then designated as male and female households alternatively. From the male households one eligible male member was selected by simple random sampling using the lottery method. Similar procedure was also followed for female households. If the subject selected with lottery method was found absent, the family was then requested to ensure the presence of that person in the forthcoming visit. Still if the person was not available in three consecutive visits, then that household was not considered and another household was chosen.

Survey technique: The pre-intervention phase of the study lasted for 6 months followed by 12 months of intervention phase and then further followed by 6 months of post-intervention phase. In Pre-intervention Phase, all the subjects fulfilling the inclusion criteria and giving the written informed con-

sent were included in the study. Afterwards, the baseline data was collected from these subjects. The data regarding these risk factors was collected using the pre-designed, pretested and semi-structured interview schedule (based on WHO steps approach, IDSP Non-Communicable risk factor survey, International Physical Activity Questionnaire (IPAQ) and Goldberg Mental Stress Questionnaire). A fasting blood sample was collected from the included participants to measure the fasting blood glucose levels. Lipid profile was measured for only those subjects who were at high risk of developing NCDs. The risk factors were identified i.e. Blood pressure ≥ 140/90 or history of blood pressure present, FBS ≥126mg/dl or history of diabetes, age more than 40 years and raised waist hip ratio. Presence of any two out of the four risk factors mentioned above were considered under the high-risk category for developing non-communicable diseases. Lipid profile testing included total cholesterol, high density lipoprotein, low density lipoprotein and triglyceride levels.

In Intervention Phase, the subjects in the intervention group were contacted on their mobile phones via telephone calls every fortnight. All these calls on an average lasted for about 20 min during which in addition to reiterating importance of modifiable risk factors, queries of the subjects were addressed and positive reinforcement regarding the modifiable risk factors was given. Mobile text messages (SMS) were also sent to the subjects which addressed one NCD risk factor at a time and were sent daily on rotation basis for different NCD risk factors. The text messages were sent in Hindi language for better understanding and compliance by the study subjects. One example each of the messages related to specific risk factors are shown in the box below:

Tobacco	तमबाकु के नशे को छोड दो, अपने जीवन को नया मोड दो, खुद को जगा दो, तमबाकु के नशे को भगा दो।
Alcohol	क्या आपने सोचा कैसे यह शराब करती है आपके आय और स्वस्थ्य को ख़राब, आज ही छोड़े शराब का नशा देखें निकटतम नशामुक्ति केंद्र की दिशा।
Physical Activity	सिर्फ़ दिन के ३० मिनट व्यायाम या सैर करने से रहैं सदा फ़िट, इस छोटी सी आदत से बनाए ज़िंदगी सुपरहिट।
Diet	जो खाए ज्यादा चिकना खाना, जैसे समोसा या पकोडा, उसको पकडे मोटापा, बीपी, शुगर आर दिल का दौरा।
Stress	योग या ध्यान मन के लिए अच्छा व्यायाम है, यह आपके तनाव के स्तर को कम करता है।
Diabetes	स्वास्थ्य आहार, नियमित व्यायाम और नियमित दवा शुगर को सामान्य रखने के ३ मुख्य आधार हैं।
Hypertension	बीपी को नियंत्रित करने के लिए अपने भोजन में नमक को कम करना आवश्यक है।

In post-intervention phase, the interview and examination were conducted again and investigations were repeated.

Statistical analysis: Data collected was analysed using statistical software (SPSS-22). Quantitative data was expressed in terms of mean and standard deviation and difference in mean was tested by Student t-test (for normal data) and Mann Whitney-U Test (for non-normal data). Qualitative or categorical data was expressed in terms of percentages and the difference was tested by Chi-square test or Fisher's exact test. Pre and post intervention quantitative data was analysed using paired t-test (for normal data) and Wilcoxon Signed Rank Test (for non-normal data). Pre and post intervention qualitative data was analysed using McNemar test (for two category variable) and Marginal Homogeneity test (for more than two category variable). p-value of <0.05 was considered statistically significant.

Approval of Institutional Ethical Review Board: The ethical approval was obtained from the Institutional Ethics Committee (Letter No. SU/SMS&R/76-A/2018/164 dated 6/12/2018).

RESULTS

A total of 480 subjects were enrolled in the present study. Out of these, 240 subjects were allocated to Intervention group and 240 subjects were allocated to Control group. Pre intervention data was collected from all the subjects. During intervention period, 6(2.5%) subjects were lost to follow up from the intervention group and among the control group, 13(5.4%) subjects were lost to follow up. Therefore, post-intervention data was collected among 234 subjects in Intervention group and 227 subjects in Control group.

Table 1 depicts distribution of various risk factors of NCD in quantitative terms in intervention and control groups. The mean baseline values for behavioural and biochemical risk factors were almost similar in Intervention and Control group except for FBS. However, the mean baseline values of Anthropometric and Physiological risk factors were statistically different in both the groups. The comparison of mean baseline values of the risk factors for NCDs was also carried out between the subjects who were lost to follow-up(n=19) with those who completed the study(n=461) and no statistically significant difference was found between the two groups.

Table 2 depicts pre and post intervention data of all NCD risk factors in intervention and control group in quantitative terms. In intervention group, significant reduction was found among all the risk factors of NCD's except with Waist circumference, Goldberg mental stress scoring and HDL levels. In control group, a significant increase in risk factor was observed about physical activity, BMI, FBS, waist circumference and waist hip ratio.

Table 1: Baseline Distribution of various risk factors of NCDs in Intervention and Control Group in quantitative terms

Risk Factors	Intervention Group (n=240)	Control Group (n=240)	Total (n=480)	U Value	p-value
Behavioural Risk Factors					
Smoking (No. of times per day)	7.9±6.9	6.3±6.1	7.1±6.5	25029.0	0.11
Smokeless tobacco (No. of times per day)	2.4±2.7	2.8±3.1	2.6±2.9	27292.5	0.290
Alcohol Consumption (Standard drinks per day)	2.9±5.1	2.3±3.8	2.6±4.5	27367.5	0.270
Fruits & vegetable consumption (Serving per day)	4.7±1.6	4.9±1.4	4.8±1.5	26643.5	0.147
Per Capita Salt Consumption per day(gms/day)	8.1±5.0	7.7±5.03	7.9±5.03	25809.5	0.49
Physical Activity (MET min/ week)	5976.7±4004.2	5804.9±3483.6	5890.8±3750.0	28791.5	0.996
Anthropometric Risk Factors					
Body Mass Index (BMI)(kg/m^2)	22.0±2.1	21.3±1.7	21.7±1.9	21566.5	**<0.001**
Waist circumference(cm)	85.8±11.4	78.9±10.3	82.4±11.4	18516.0	**<0.001**
Waist Hip ratio	0.9±0.0	0.9±0.03	0.9±0.3	25140.5	**0.016**
Physiological Risk Factors					
Systolic Blood Pressure(mm/Hg)	122.7±12.4	118.6±13.2	120.6±13.5	23332.0	**<0.001**
Diastolic Blood Pressure (mm/Hg)	80.7±7.3	79.4±8.1	80.07±7.7	25823.5	**0.049**
Goldberg Mental Stress Score	4.2±1.4	3.5±1.4	3.9±1.4	20818.0	**<0.001**
Biochemical Risk Factors					
Blood sugar					
Fasting Blood Sugar(mg/dl)	107.4±29.1	102.04±27.2	104.7±28.3	25327.5	**0.022**
Lipid profile	**(n=102)**	**(n=105)**	**(n=207)**		
Total Cholesterol(mg/dl)	167.6±38.3	164.9±34.4	166.2±36.3	4878.0	0.268
Total triglyceride (mg/dl)	146.6±75.1	147.2±58.1	146.9±66.9	5047.0	0.475
High density Lipoprotein (mg/dl)	45.3±15.4	41.8±10.2	43.5±13.1	4645.5	0.099
Low density Lipoprotein*(mg/dl)	93.2±28.8	91.3±22.3	92.2±25.7	t=0.524	0.601

Values are in Mean ± SD;
*Unpaired t test was applied in LDL due to normal distribution of data

Table 2: Change in distribution of various risk factors of NCDs after mHealth Intervention in quantitative terms

	Intervention Group			Control Group		
	Baseline (n=240)	**Post-intervention (n=234)**	**p-value**	**Baseline (n=240)**	**Post-Intervention (n=227)**	**p-value**
Behavioural Risk Factors						
Smoking (No. of times/day)	7.9±6.9	5.1±4.6	**<0.001**	6.3±6.1	5.5±5.2	**<0.001**
Smokeless tobacco use (No. of times/day)	2.4±2.7	2.1±2.3	**<0.001**	2.8±3.1	2.6±2.9	**0.025**
Alcohol Consumption (Standard drinks /day)	2.9±5.1	2.4±4.0	**<0.001**	2.3±3.8	2.4±3.9	0.828
Fruits & vegetable consumption (Serving/day)	4.7±1.6	5.5±1.4	**<0.001**	4.9±1.4	4.9±1.4	0.381
Per Capita Salt Consumption (gms/day)	8.1±5.02	5.8±1.7	**<0.001**	7.7±5.0	7.5±2.7	0.458
Physical Activity (MET min/ week)	5977 ±4004	6081 ±3969	**<0.001**	5805 ±3484	5633 ±3326	**0.011**
Anthropometric Risk Factors						
Body Mass Index	22.0±2.1	21.8±1.8	**<0.001**	21.3±1.7	21.4±1.6	**<0.001**
Waist circumference(cm)	85.8±11.4	85.7±11.3	0.07	78.9±10.3	79.2±10.1	**<0.001**
Waist Hip ratio	0.88±0.036	0.87±0.034	**<0.001**	0.87±0.03	0.87±0.03	**0.005**
Physiological Risk Factors						
Systolic Blood Pressure (mm/Hg)	122.7 ±12.4	120.0 ±12.3	**<0.001**	118.6±13.2	117.7±13.4	**0.016**
Diastolic Blood Pressure (mm/Hg)	80.7 ±7.3	79.7 ±6.8	**0.002**	79.4±8.1	79.4±7.9	0.863
Goldberg Mental Stress Score	4.2±1.4	4.2±1.4	0.100	3.5±1.4	3.9±1.4	**<0.001**
Biochemical Risk Factors						
Fasting Blood Sugar (mg/dl)	107.4 ±29.1	102.9 ±25.3	**<0.001**	102.0 ±27.2	103.5 ±26.9@	**0.014**
Lipid profile#						
Total Cholesterol (mg/dl)	167.6 ±38.3	160.2 ±29.5	**0.041**	164.9 ±34.4	165.5 ±34.9	0.399
Total triglyceride (mg/dl)	146.6 ±75.1	129.5 ±52.3	**0.001**	147.2 ±58.1	141.6 ±61.7	0.328
High density Lipoprotein (mg/dl)	45.3 ±15.4	46.7 ±8.6	0.304	41.8 ±10.2	46.1 ±9.9	**0.001**
Low density Lipoprotein* (mg/dl)	93.2 ±28.8	86.3 ±21.9	**0.006**	91.3 ±22.3	89.5 ±22.0	0.801

Values are in Mean ± SD; *Paired t test was applied in case Low Density Lipoproteins due to normal distribution of data

@ FBS of 223 cases were available.

In the intervention group, baseline lipid profile data were available for 102 participants, while post-intervention data were available for 101 participants. Similarly, in the control group, baseline data were available for 105 participants, but post-intervention data were only available for 100 participants.

Table 3: Change in distribution of Behavioural and Anthropometric risk factors of NCDs after mHealth Intervention in categorical terms

	Intervention Group			Control Group		
	Baseline (n=240)	Post-intervention (n=234)	p-value	Baseline (n=240)	Post Intervention (n=227)	p-value
Behavioural Risk Factors						
Smoking						
Non-Smoker	80(33.3)	81(34.6)	**<0.001**	99(41.2)	96(42.3)	**0.02**
Light	5(2.1)	29(12.4)		4(1.7)	2(0.9)	
Moderate	50(20.8)	87(37.2)		48(20.0)	61(26.9)	
Heavy	105(43.8)	37(15.8)		89(37.1)	68(30.0)	
Smokeless Tobacco Use						
Non-User	117(48.8)	113(48.3)	**<0.001**	117(48.8)	111(48.9)	0.157
Light	70(29.2)	81(34.6)		52(21.7)	53(23.3)	
Moderate	50(20.8)	39(16.7)		66(27.5)	60(26.4)	
Heavy	3(1.2)	1(0.4)		5(2.1)	3(1.3)	
Alcohol Consumption						
Non-Alcohol User	148(61.7)	143(61.1)	**0.001**	162(67.5)	154(67.8)	0.414
Light	31(12.9)	42(17.9)		21(8.8)	18(7.9)	
Moderate	42(17.5)	37(15.8)		46(19.2)	43(18.9)	
Heavy	19(7.9)	12(5.1)		11(4.6)	12(5.3)	
Physical Activity						
Low	10(4.2)	4(1.7)	**0.011**	9(3.8)	9(4.0)	0.405
Moderate	60(25.0)	58(24.8)		59(24.6)	53(23.3)	
Heavy	170(70.8)	172(73.5)		172(71.7)	165(72.7)	
Fruits & vegetable consumption						
Low (<5 servings/day)	110(45.8)	63(26.9)	**<0.001**	97(40.4)	99(43.6)	0.093
Normal (≥5servings/day)	130(54.2)	171(73.1)		143(59.6)	128(56.4)	
Per Capita Salt Consumption per day						
Normal (≤5gm/day)	17(7.1)	73(31.2)	**<0.001**	26(10.8)	32(14.1)	0.115
Raised (>5gm/day)	223(92.9)	161(68.8)		214(89.2)	195(85.9)	
Anthropometric Risk Factors						
Body Mass Index						
Underweight	10(4.2)	6(2.6)	**<0.001**	5(2.1)	5(2.2)	0.225
Normal	159(66.2)	185(79.1)		205(85.4)	194(85.5)	
Overweight	55(22.9)	29(12.4)		23(9.6)	17(7.5)	
Obese	16(6.7)	14(6.0)		7(2.9)	11(4.8)	
Waist circumference						
Normal	115(47.9)	110(47.0)	1	163(67.9)	153(67.4)	0.25
Raised	125(52.1)	124(53.0)		77(32.1)	74(32.6)	
Waist hip Ratio						
Normal	134(55.8)	144(61.5)	**0.007**	159(66.2)	148(65.2)	0.549
Raised	106(44.2)	90(38.5)		81(33.8)	79(34.8)	

Figures in parenthesis are percentages

Table 3 depicts pre and post intervention data of behavioural and anthropometric risk factors of NCD's in categorical terms in Intervention and Control groups. In intervention group, statistically significant reduction was observed for all the behavioural and anthropometric risk factors of NCDs.

Table 4 depicts pre and post intervention data of physiological and biochemical risk factors of NCDs in categorical terms in intervention and control groups. In intervention group, statistically significant reduction was found among all physiological and biochemical risk factors of NCDs except with Goldberg mental stress score. However, in the control group, there was a significant increase in Goldberg mental stress score.

DISCUSSION

The present study was conducted to find out the prevalence of the modifiable risk factors of NCDs and the effect of mHealth intervention on reducing these risk factors. A total of 480 subjects were included in our study of which 241 were males and 239 were females. After initial assessment, the subjects were divided into intervention and control groups with participants in each group.

The findings of the study indicate that adopting mHealth intervention such as phone calls and SMS for Behaviour Change Communication (BCC) can be successful in lowering the prevalence of unhealthy diet and physical inactivity, which are two of the behavioural risk factors for NCDs. Many other researches in industrialized nations too have found that mobile text messages-based interventions are effective in promoting physical activity and healthy diet. Another study conducted in United Kingdom also emphasized that mobile text messages-based intervention significantly increased the physical activity level.[8]

Table 4: Change in distribution of Physiological and Biochemical risk factors of NCDs after mHealth Intervention in categorical terms

	Intervention Group (n=240)			Control Group (n=240)		
	Baseline (n=240)	**Post-Intervention (n=234)**	**p-value**	**Baseline (n=240)**	**Post Intervention (n=227)**	**p-value**
Physiological Risk Factors						
Blood Pressure						
Normal	71(29.6)	104(44.4)	**<0.001**	107(44.6)	106(46.7)	0.083
Pre- HTN	128(53.3)	98(41.9)		83(34.6)	79(34.8)	
Stage 1 HTN	36(15.0)	32(13.7)		48(20.0)	41(18.1)	
Stage 2 HTN	5(2.1)	0(0.0)		2(0.8)	1(0.4)	
Goldberg Mental Score						
Normal (0-2)	30(12.5)	31(13.2)	0.251	55(22.9)	34(15.0)	**<0.001**
Borderline (3)	40(16.7)	41(17.5)		69(28.8)	50(22.0)	
Non- psychotic psychiatric illness (>3)	170(70.8)	162(69.2)		116(48.3)	143(63.0)	
Biochemical Risk Factors	**(n=240)**	**(n=233)**		**(n=240)**	**(n=223)**	
Fasting Blood Sugar						
Normal	145(60.4)	152(65.2)	**<0.001**	159(66.2)	152(68.2)	**0.014**
Impaired	28(11.7)	37(15.8)		9(3.8)	15(6.7)	
Diabetic	67(27.9)	44(18.9)		72(30.0)	56(25.1)	
Lipid Profile	**(n=102)**	**(n=101)**		**(n=105)**	**(n=100)**	
Total Cholesterol						
Normal	81(79.4)	95(34.1)	**0.001**	91(86.7)	87(87.0)	0.687
Raised	21(20.6)	6(5.9)		14(13.3)	13(13.0)	
Total triglyceride						
Normal	62(60.8)	73(72.3)	**0.031**	66(62.9)	65(65.0)	1
Raised	40(39.2)	28(27.7)		39(37.1)	35(35.0)	
High density Lipoprotein						
Normal	61(59.8)	83(82.2)	**<0.001**	61(58.1)	72(72.0)	**0.01**
Low	41(40.2)	18(17.8)		44(41.9)	28(28.0)	
Low density Lipoprotein						
Normal	89(87.3)	98(97.0)	**0.006**	100(95.2)	97(97.0)	1
Raised	13(12.7)	3(3.0)		5(4.8)	3(3.0)	

Figures in Parenthesis are percentages.

A Swedish study looked at the role of a weight loss program provided through mobile text messages. The program addressed nutrition and physical activity regulation and reported that after a year, the intervention group had shed much more weight than the control group.[9]

A review published in 2016 evaluating 15 research articles on mHealth and e-health treatments for promoting healthy diets and physical exercise in low- and middle-income (LAMI) countries found that e-health and mHealth interventions could be beneficial in promoting physical activity and diet quality. Overall, the research found that 50% of the identified e-health and mHealth interventions were effective in boosting physical activity and 70% of the identified interventions were helpful in improving healthy diets. Both these interventions helped in two-way communication with the subjects which in turn was a step towards changing the health status and providing positive reinforcement to the subjects.[6] In another cohort study conducted by Pfammatter A et al[10] in India, it was observed that the intervention group receiving messages had improved fruit, vegetable, and fat consumption (P<0.01) as compared with controls but no significant improvement was seen in physical activity.

Overall prevalence of low fruits and vegetable consumption in our study was found to be 43.1% (42.7% among males and 43.5% among females). This finding is not in concordance with the study conducted by Srivastav S et al[7] in the rural area of Gautam-Buddha Nagar, Uttar Pradesh (2017) where lower consumption of fruits and vegetables was observed in 89.6% males and 90.1% of the females. Also, in a study conducted by Thakur JS et al[11] in rural areas of Haryana (2019), the overall prevalence of lower fruits and vegetables consumption was found to be 99.2%, with prevalence in males being 99% and 99.5% in females. Overall prevalence of low fruits and vegetables consumption was observed to be 48.1% in a study conducted by Shankar H et al[12] in Cholapur and Sewapuri rural blocks, Varanasi (2019) which was almost similar to the present study. Low fruits and vegetables consumption in our study was found to be lowest in the age groups 18-29 years (23.9%) as compared to 100% in elderly people which was in contrast to a study conducted by Thakur JS et al[11] in rural areas of Haryana (2019), where prevalence was found to be similar in all the age groups (99.0%).

Regarding blood sugar levels, our study showed a significant decline in fasting blood sugar levels

among intervention group as compared to the control group. The study conducted by Pfammatter A et al[10] in India also showed that receiving diabetes-related text messages designed to enhance awareness of diabetes risk factors displayed greater improvement in diabetes preventive behaviours over a 6-month period among the intervention group. Fewer participants in intervention group demonstrated health behaviour decline compared with controls.

The present study also showed a significant reduction in the substance abuse among intervention group such as smoking, and consumption of smokeless tobacco and alcohol. Similar findings were observed in the systematic review carried out by Krishna S et al.[13] in which it was observed that the messages which were sent for diabetes and smoking cessation had a significant impact and therefore lots of improvements were noted in compliance with medicine taking, asthma symptoms, HbA1C, stress levels, smoking quit rates, and self-efficacy. The present study also showed that the intervention group had significant reduction in Body-Mass Index (BMI) and Waist-Hip Ratio (WHR) as compared to the control group. Similar finding was observed in the study conducted by Partridge SR et al[14] in Greater Sydney Area, NSW, Australia (2015), in which it was seen that after a period of 3 months, the intervention group weighed 2.2 kg lighter than control group. The experimental group participants consumed more of vegetables and less of sugary soft drinks and energy-dense takeout meals compared to control group. They also increased their total physical activity by 1.3 days compared to controls.

It was observed in the present study that both the mHealth features i.e. phone calls and SMSs helped in two-way communication with the subjects which in turn was a step towards changing the health behaviour and providing positive reinforcement to the subjects. Integration of these mHealth interventions into the primary health care through family physicians and primary health care providers can be made a routine practice. The health counselling provided through family physicians and primary health care providers can be reiterated through continuous text messages and phone calls. This will provide motivation and positive reinforcement to the community members for adopting health lifestyles and reducing the burden of NCD risk factors.

The major strength of this study is that it assesses the effect of an innovative and cost-effective approach i.e. mHealth in reducing the risk factors of NCDs. Another strength of the study is that adequate sample size has been included in the study and therefore, the findings can be generalized to the reference population.

Conclusion

Our study has shown that mHealth can be used to promote health and change people's lifestyles among the rural community. Considering the increasing morbidity and mortality due to NCDs in the Indian population, technology-based interventions like mHealth that may easily reach the people are required. For long term follow-up, the findings of the study have been integrated with the Family Adoption Program introduced in Community Medicine. Through this program, all the study subjects in both intervention group as well as control group are being followed up by the under-graduate medical students along with the support of Medical Social Workers and specialist doctors. In this way, the study has long term impact to promote persistent change in behavioural and physiological risk factors among study subjects to control NCDs.

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