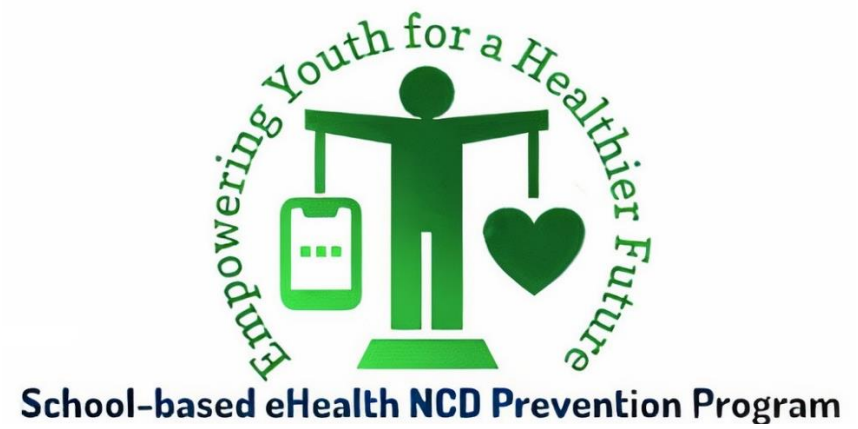

School-based eHealth NCD Prevention Program to Improve Awareness in Adolescents from Urban Pakistan

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Document Date: 14- December- 2023

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1. Introduction

Non-communicable diseases (NCDs) and their risk factors are posing a significant global public health concern(1). Non-communicable diseases (NCDs) pose a substantial threat to global public health, particularly in low- and middle-income countries (LMICs), where they account for a disproportionately high burden of mortality and morbidity (2). The next generation, which consists of children and adolescents, is equally susceptible to NCD development. NCDs have a catastrophic effect on premature morbidity, mortality, and economic loss (3). Research indicates that a significant proportion of premature deaths in adulthood can be attributed to health-related behaviors initiated in childhood and adolescence(4, 5). These behaviors, such as overweight/obesity, physical inactivity, substance use, and poor nutrition, contribute to the development of diseases and negative health outcomes later in life (5). The World Health Organization (WHO) has warned about the growing public health concern of NCD adolescent (6). The significance of this age period is further highlighted by the fact that many critical health problems affecting adults have their origins in adolescence (7, 8). As youth and adolescents transition into adulthood, individuals experience considerable physical, psychological, and emotional changes, and their social responsibilities alter significantly in the eyes of their society and culture. Additionally, this is a crucial time for them to develop healthy behaviors to improve their current and long-term well-being (9).

With more than 220 million population, Pakistan is the fifth most populated country in the world (10). Among NCDs, cardiovascular diseases, mental disorders, and diabetes are rising (11). Around 45% population under the age of 18 (12).Thus, it is important to recognize and highlight the importance of child and adolescent health as a crucial element of their overall development and well-being (13). Like the rest of the low middle-income countries, adolescents in Pakistan are exposed to a variety of risk factors for NCDs, including less consumption of fruits and vegetables (14), obesity(15), sedentary lifestyle(16, 17), and cigarette smoking(18, 19), etc. The unavailability of places for physical exercise in schools and outside of the schools, lack of awareness about the benefits of physical activity, and inadequate time allotted by teachers and parents are the factors of physical inactivity (20).

In Hyderabad, Sindh, a cross-sectional survey 2013 revealed that 12% of adolescents were obese and 8% were overweight; boys, students from middle-class families, and those in the younger age groups had the highest prevalence of obesity (21). A cross-sectional study was conducted with a sample of 3,551 students from 52 schools in central Punjab province. The results showed that the prevalence of underweight, normal weight, overweight, and obesity in Pakistani school-aged children and adolescents was 21.9%, 66.9%, 5.8%, and 5.4%, respectively (22). A school based study conducted in Pakistan aimed to identify preventable risk factors for non-communicable diseases (NCDs) among

414 adolescents (23). The study findings revealed a high prevalence of unhealthy diets (80%), physical inactivity (54%), smoking (14%), betel nut chewing (37%), and oral tobacco use (24%) among the participants. Gender differences were observed, with girls more inactive and boys more likely to smoke and use betel nuts. A systematic review and meta-analysis conducted in 2020 aimed to determine the prevalence of physical activity (PA) among Pakistani adolescents aged 13-15 years. After analyzing 15 articles with a total sample size of 10,651, the weighted pooled prevalence of PA among adolescents was found to be 36.0%. The findings highlight the low prevalence of PA among Pakistani adolescents and emphasize the need for formal strategies to promote physical activity to improve health outcomes and prevent non-communicable diseases (NCDs).

In 2015, a meta-analysis aimed to quantify the effectiveness of interventions promoting physical activity in girls aged 12 to 18 (24). Forty-five studies were included, and the results indicated that while the average treatment effect was significant, it was small. Moderator analyses revealed that theory-based interventions, conducted in schools, girls-only programs, interventions targeting younger girls, and those employing multi-component strategies showed larger effects. Overall, the study findings suggest that increasing physical activity in adolescent girls can be challenging, but certain approaches appear successful. A study in 2022 examined the association between fruit and vegetable (FV) intake and body composition among adolescents in Karachi, Pakistan (25). It found that 38.7% of adolescents had inadequate FV intake (< 3 servings). Factors such as age over 15 years, female gender, and higher body fat percentage were associated with low FV intake. The findings emphasize the importance of addressing low FV intake among adolescents and implementing interventions to promote healthier eating habits.

A study conducted in 2022 aimed to develop and evaluate an intervention strategy for increasing physical activity among adolescents in Pakistan using the social-ecological model. The 8-week intervention involved delivering intervention materials to the intervention group once a week. The results showed a significant increase in physical activity participation among the intervention group compared to the control group, indicating the effectiveness of the intervention based on the social-ecological model in improving physical activity among school adolescents in Pakistan. Enhancing health and educational outcomes in schools can improve career opportunities, better physical and emotional health, and subsequent benefits for future generations (26). The Ottawa Charter for Health Promotion, created by WHO in 1986, introduced the idea of health-promoting schools (27, 28). A systematic review in 2020 examined the effectiveness of school-based interventions in promoting physical activity, and physical fitness, and preventing obesity among primary and secondary school students. Nineteen studies met the eligibility criteria out of 395 screened. The

findings suggest that school-based interventions can significantly improve outcomes related to obesity, physical activity, and physical fitness (29). A health-promoting school involves people from the school and the community collaborating to give students comprehensive and constructive experiences and structures to encourage and promote their health. Health promotion always plays a fundamental role in implementing health education strategies to modify behaviour on a willful basis. This involvement also includes self-organized and autonomous engagement (30).

According to the Pakistan Social and Living Standards Measurement Survey (PSLM) 2019-20, the overall literacy rate for individuals aged 10 years and above in Pakistan is approximately 60% (31). According to the National Education Management Information System (NEMIS) 2020-21 (32), approximately 20.1 million students were enrolled in primary education (grades 1-5) in Pakistan, while around 7.3 million students were enrolled in middle education (grades 6-8). In secondary education (grades 9-10), the number of enrolled students was approximately 2.3 million, and for higher secondary education (grades 11-12), there were around 3 million students in Pakistan.

These statistics demonstrate that a significant portion of our children and adolescents now have access to education in schools, which opens up several options for health education programs for them, allowing them to increase society's economic and social productivity (33).

The eighth Pakistani five-year plan (34) stated that there was no general youth programme for the adolescents in Pakistan. Although certain recommendations were made, such as the use of various communication channels, developing new ideas, media utilization, and message targeting for specific age groups of individuals, there was rarely any practical implementation. Being a developing country with limited resources, it is crucial to utilize the captive audience of school students and instructors with the resources available and a collective effort; an approach that would hold everyone accountable for health promotion.

In Pakistan, very limited research studies have been conducted on the effectiveness of evidence-based therapies and the unmet demand for adolescent services (35). It is critical to consider the possible alternatives for boosting the well-being of our adolescents given the high burden of morbidities and shortage of services. In this context, schools in Pakistan can serve as an important forum for improving the health of adolescents and children.

A feasibility trial in 2023 was conducted in pre-adolescent school children from a lower middle-income country, the School Health Education Program in Pakistan (SHEPP) to assess its viability and impact on health-related factors (36). The study involved health education and physical activity interventions for children, teacher training, and parent awareness sessions conducted over 10 months.

One school received the intervention while another followed routine activities. Out of 1191 eligible children, 982 were recruited, with a retention rate of 92.8% at the 10-month follow-up. Physical activity increased significantly in the SHEPP group compared to the routine activity group, as did vegetable intake. Cardiometabolic risk factors like blood pressure, BMI, and waist circumference also showed favorable changes in the intervention group. The study suggests that SHEPP's intervention is feasible and may contribute to healthier lifestyles among children, warranting further exploration, particularly in the transition to adolescence and adulthood.

Another study based on quassi experimental design in 2022 was conducted to determine the effectiveness of an 8-week intervention using the social-ecological model to enhance physical activity (PA) among 618 Pakistani school students in Rawalpindi (37). The intervention encompassed individual, interpersonal, and organizational levels of change, with sessions addressing benefits of PA, motivation, self-efficacy, social support, family involvement, PA environment, safety, policy, and culture. Quantitative pre- and post-test measures revealed a significant increase in PA participation for the intervention group compared to the control group, indicating the effectiveness of the intervention in improving adolescents' PA within the school setting.

The overall picture drawn from the literature demonstrates the significance of providing young adults with health education on a global level. The main points of emphasis are the methods and materials used to educate them. Second, WHO's proposed framework for health promotion is based on initiatives that have been shown effective globally (38). The published studies demonstrated a need to provide students with the necessary knowledge and skills to make informed decisions about their health. However, significant improvements in health education require robust strategies such as trials and the design of model strategies to meet both immediate and long-term needs. (29). In Pakistan, there is a notable absence of comprehensive school health promotion programs, and existing research on effective intervention strategies for schoolchildren and adolescents is limited. Addressing this gap is crucial, necessitating the introduction of an innovative and accessible solution. One such solution involves harnessing digital interventions to enhance health awareness among students. This approach offers affordability, accessibility, and availability, potentially bridging the current void in health education within school settings

Digital platforms offer exceptional prospects for promoting overall health, including healthy diet, physical activity, and the prevention of chronic diseases (39-42). A 2018 systematic review (43) explored mobile app-based health promotion programs for the general population. Twelve randomized controlled trials were included, focusing on diet, physical activity, and lifestyle improvement. The studies demonstrated that mobile app users achieved better health outcomes than non-users. The

findings indicate the effectiveness of mobile app-based interventions in promoting health behaviors among disease-free individuals.

A systematic review conducted in 2017 investigated the effectiveness of Diabetes Prevention Program (DPP)-based lifestyle interventions delivered through electronic, mobile, and telehealth platforms in promoting weight loss (44). The review included 22 studies with 26 interventions, primarily involving white and college-educated participants. The overall estimate showed a mean percentage weight loss of -3.98% across all interventions. Stand-alone eHealth interventions had a subtotal estimate of -3.34%, while interventions with remote or in-person behavioral support from counselors had higher estimates of -4.31% and -4.65% respectively.

The use of digital platforms is becoming increasingly common as a means of accomplishing health objectives, especially among adolescents and youth as a means of addressing inadequacies in the health system including lack of access (45). The rapid advancement of digital technology, including the widespread use of mobile phones, social media, and online games, presents valuable opportunities for intervention among adolescents. These platforms offer innovative ways to engage and reach adolescents, providing new avenues for promoting health and behavior change (46). Mass media and social marketing interventions have proven effective in changing social norms and empowering adolescents, their families, and communities. These interventions serve as a platform for grassroots movements, fostering positive behavioral change and creating a supportive environment for adolescents and the broader community (47, 48).

School-aged children and adolescents are engaged in various interventions, including smartphone applications (41), text messaging for health promotion, peer-to-peer interactions on networking sites and social media, and counseling for mental health and well-being support (49-51). According to a 2017 systematic review (52), adolescents frequently access digital media, which may provide an accessible and affordable opportunity to influence their behavior. The review's findings indicate that digital initiatives that incorporate health education, self-monitoring, goal-setting and parental participation can significantly improve adolescents' physical activity (PA)) and dietary behaviors.

A systematic review was conducted in 2021(53) to identify global digital health interventions for universal health promotion in school-aged children and adolescents. The review found that digital interventions offer great potential to promote universal health and address health system shortcomings such as lack of access to services, resources, and education. The review also states that the digital health interventions may significantly impact the behaviors and lifestyles of our growing generations, lending to long-term, positive benefits in human health and development. A randomized controlled

trial in 2020 aimed to assess the impact of a web-based health education and consultation program on the health promotion behaviors and e-health literacy of adolescents in Turkey (54). The intervention involved 132 students of grade 11 receiving web-based health education grounded in health promotion theory, while 120 students of grade 11 formed the control group. Results after three months revealed significantly greater improvements in the intervention group's total Adolescent Lifestyle Questionnaire scores and e-health literacy compared to the control group. A cluster randomized trial in 2012 among 883 students aged 12-13 years in twenty schools in the Netherlands to evaluate the effectiveness of the Web-based computer-tailored intervention called FATaintPHAT (55). The intervention aimed to improve physical activity, reduce sedentary behavior, and promote healthy eating to prevent excessive weight gain in adolescents. The intervention group received eight lessons over ten weeks, while the control group had no intervention; the teachers were asked to deliver the content of the intervention to the students in classrooms. The intervention showed no significant impact on BMI and waist circumference, but it was associated with reduced consumption of sugar-sweetened beverages and snacks, increased vegetable intake, and improved fruit consumption among students at risk. A feasibility study of an eHealth intervention was conducted in 2020, using the "SanoyFeliz" application, aimed at improving healthy habits among adolescents in Spain (56). The research study employed a pre-post-test design, involving 139 students in the intervention group and 91 in the control group, aged 11 to 15 years. The intervention group accessed a web platform with social networking features, receiving daily nutrition and physical activity information, while the control group had no such access. Results from self-reported data gathered before and after the 14-week intervention indicated significant positive changes in age-adjusted body mass index percentile, physical activities, and eating habits among the intervention group compared to the control group. This suggests that eHealth interventions have the potential to foster healthier habits, although further investigation is necessary to assess long-term adherence to these habits

Limited research studies have been conducted in Pakistan on the effectiveness of evidence-based therapies for adolescents, leading to unmet service demand (35). Schools can play a vital role in promoting health among adolescents and children (57). Digital platforms, particularly mobile apps, show promise in promoting overall health and preventing chronic diseases (39-42). Digital platforms offer innovative ways to engage and reach adolescents, addressing health system inadequacies(46). Implementing a school-based eHealth intervention can effectively raise NCDs awareness among students, providing health education and fostering long-term positive benefits for improved health behaviors and human development (58). The proposed research aims to assess the feasibility and

effectiveness of a school-based eHealth-NCD prevention program intervention to improve adolescents' knowledge, attitude, and practices regarding NCDs and associated risk factors.

1.1. Research Questions

1. What are the barriers and facilitators in conducting a school-based eHealth NCD prevention program in Pakistani secondary and higher secondary schools?
2. What are stakeholders' perceptions regarding the design and content of a school-based eHealth NCD prevention program for Pakistani secondary and higher secondary school students?
3. What is the feasibility and effectiveness of a school-based eHealth NCD prevention program in improving Pakistani secondary and higher secondary school students' knowledge, attitudes, and practices regarding NCDs and their associated risk factors?
4. What are the perceptions of secondary and higher secondary school students regarding the usefulness, acceptability and task technology fitness of a school-based eHealth NCD prevention program?

1.2. Specific Aims and Hypothesis:

1. To identify barriers and facilitators associated with implementing a school-based eHealth intervention to improve the knowledge, attitudes, and practices of secondary and higher secondary school students in Pakistan regarding NCDs and their associated risk factors.

   Hypothesis: Identifying barriers and facilitators will inform strategies to successfully implement the intervention within the given context.
2. To explore the stakeholders' perceptions regarding the design and content of the School-based eHealth NCD prevention Program to improve the knowledge, attitudes, and practices of secondary and higher secondary school students in Pakistan regarding NCDs and their associated risk factors.

   Hypothesis: Stakeholder input will refine the School-based eHealth NCD prevention Program to meet the specific needs and preferences of the target population.
3. To assess the feasibility and effectiveness of the School-based eHealth NCD prevention Program in secondary and higher secondary school in Karachi.

   Hypothesis: The school-based eHealth NCD prevention program will demonstrate feasibility in terms of successful recruitment, retention, and treatment fidelity rates exceeding 70% among secondary and higher secondary school students in Karachi, Pakistan..

4. To evaluate the effectiveness of the school-based eHealth NCD prevention program in significantly improving the knowledge, attitudes, and practices of secondary and higher secondary school students in Karachi, Pakistan, regarding NCDs and their associated risk factors, as compared to a control group not receiving the intervention.

   Hypothesis: The school-based eHealth NCD prevention program will show effectiveness in significantly improving the knowledge, attitudes, and practices of secondary and higher secondary school students in Karachi, Pakistan, regarding NCDs and their associated risk factors, as compared to a control group not receiving the intervention.

5. To explore the perceptions of students regarding the usefulness acceptability and task technology fit of the School-based eHealth NCD prevention Program in improving the knowledge, attitude, and practices of Pakistani Higher Secondary School students regarding NCDs and their associated risk factors.

   Hypothesis: The School-based eHealth NCD prevention Program will be perceived as useful, acceptable, and having a good task technology fit by Pakistani secondary and Higher Secondary School students.

2. Research Methodology

2.1. Overall flow of the studies

A sequential mixed methods design is justified for this study due to its ability to provide a comprehensive and in-depth understanding of the research questions. By combining both qualitative and quantitative approaches in a sequential manner, this design allows for a more robust exploration, validation, and explanation of the complex factors surrounding the implementation and effectiveness of a school-based eHealth NCD prevention program. The design progresses logically from initial exploration (qualitative exploration phase to validation (quantitative phase) and deeper understanding (qualitative explanation phase), enhancing the study's overall rigor and validity. This approach ensures that the insights gained from each phase inform and enrich the subsequent phases, leading to a holistic understanding of the research topic. Figure 1 illusrtates the conceptual framework of the sequential mixed-method design.

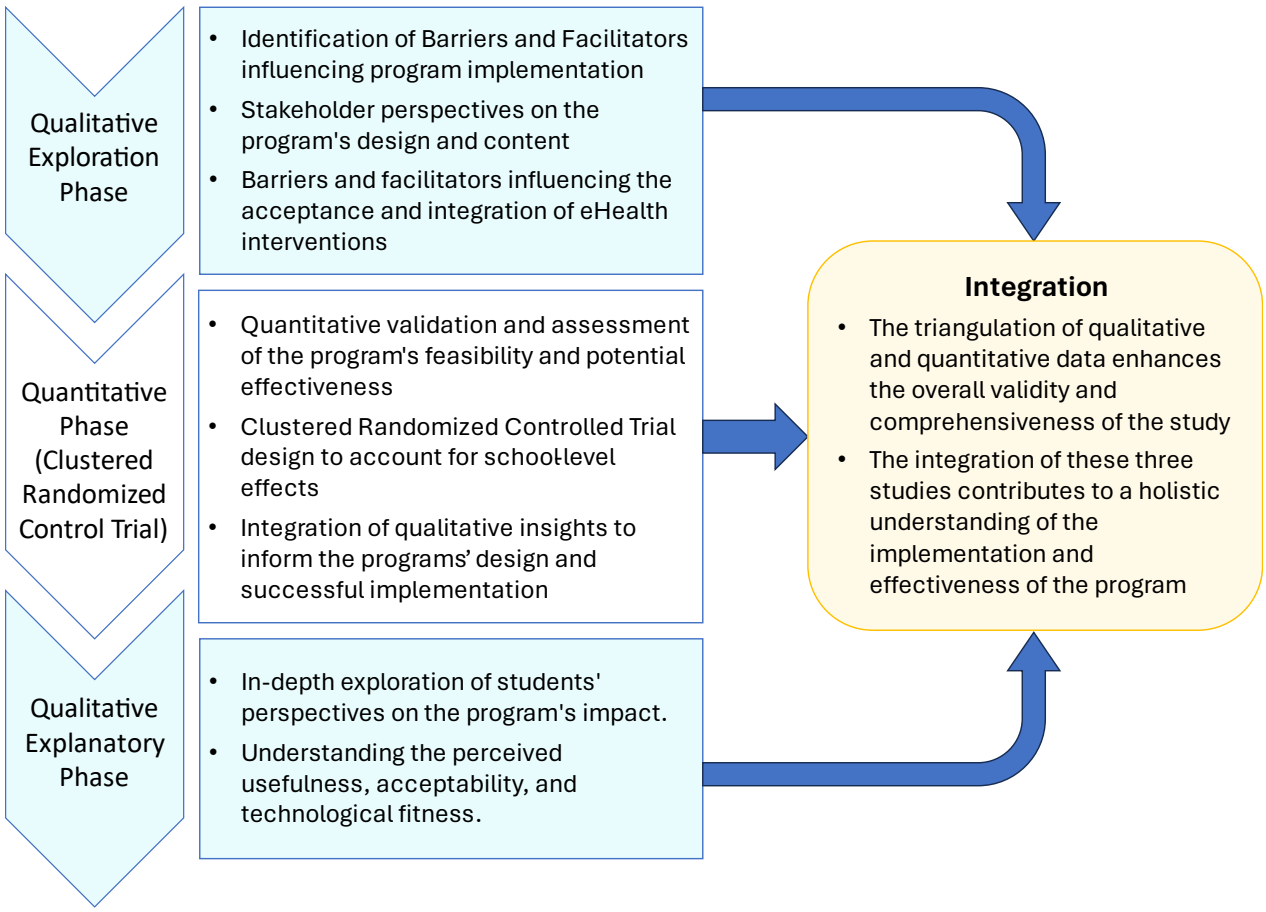

Figure 1: Conceptual framework of the sequential mixed-method design

By starting with exploratory qualitative phase, the study aims to explore the barriers, facilitators, and stakeholders' perceptions surrounding program implementation. This initial phase will yield rich contextual insights that can inform the design and content of the program. The subsequent quantitative

phase will build upon the findings from qualitative exploration phase, allowing for the systematic assessment of the program's feasibility and effectiveness using a clustered randomized controlled trial design. This sequential approach allows the researchers to utilize qualitative insights to inform the development of the quantitative phase, ensuring that the research process is informed and responsive to the complexities of the research context. The quantitative phase will then assess the feasibility and effectiveness of the intervention, validating and extending the qualitative findings. Furthermore, the final qualitative explanatory phase will provide an in-depth understanding of students' perceptions regarding the usefulness, acceptability, and technological fitness of the program, adding depth to the quantitative findings. The sequential design thus allows for triangulation of findings, enhancing the validity and robustness of the study's outcomes.

Please refer to Figure 1 and Table 1 for an overview of the studies.

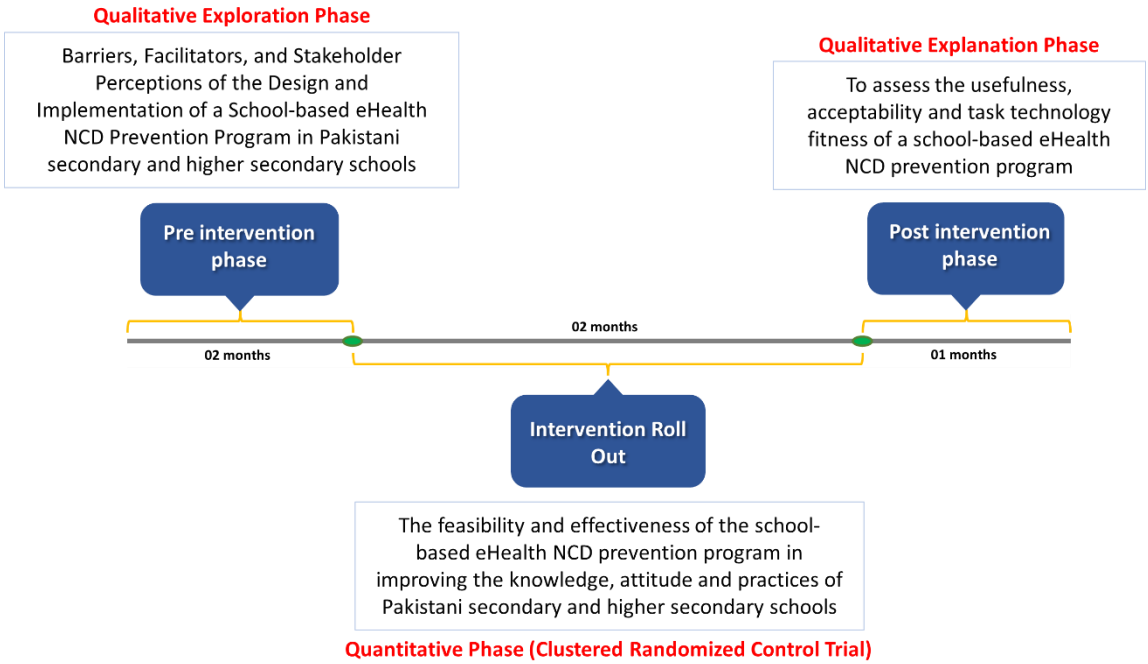

Figure 2: Summary of project phases

2.2. Study setting and study participants

The study will be conducted in Secondary and Higher Secondary Schools located in Karachi, Pakistan. In the Pakistani educational context, the term "secondary school" pertains to institutions that offer education to students in grades 9 and 10, generally covering the age range of 13 to 15 years. On the other hand, "higher secondary school" refers to educational establishments that provide instruction to students in grades 11 and 12, typically spanning the age bracket of 15 to 18 years (32). It is the level of education that follows the completion of secondary education and precedes higher education at the college or university level.

Three phase will be part of the School-based eHealth NCD prevention program, each focusing on a specific objective and targeting a distinct population. The target population includes secomdary and higher secondary school students, their parents, teachers, and administrators, including school principals, District Education Officers (DEOs), and decision-makers at the provincial education departments. The eligibility criteria for participants and the sample sizes for each study package can be found in the detailed descriptions of the phases.

Objectives	Study Design	Data collection method	Integration

Qualitative Exploration Phase
• To determine the barriers and facilitators in implementing the program
• To assess the stakeholders' perceptions regarding the design and content of the Program
	Exploratory qualitative study	• **Total 4 FGDs** (8 participants in each FGD)
		  • 2 FGDs with students
		  • 2 FGDs with Teachers
		• **KIIs with the school administrators and Parents**
			The findings inform the design and implementation of the program for the next phase

Quantitative Phase • To assess the feasibility and potential efficacy of the School-based eHealth NCD prevention program.	**Clustered Randomized control trial**	**Baseline Assessment** **2-months Intervention** • Total 6 sessions • Each session will be 30-40 minutes and three sessions will be delivered per month **Endline Assessment**	Results from this phase inform the focus of the next phase
Qualitative Explanation Phase • To assess the usefulness, acceptability and task technology fitness of the Program	**Explanatory qualitative study**	• **Total 2 FGDs with students** (8 participants in each FGD)	The findings contextualize and explain the quantitative results from the previous phase

Table 1: Overview of the studies using Mixed Method Design

3. Qualitative Exploration Phase: Barriers, Facilitators, and Stakeholder Perceptions of the Design and Implementation of a School-based eHealth NCD Prevention Program in Pakistani Secondary and Higher Secondary Schools

3.1. Research questions

- What are the barriers and facilitators in conducting a school-based eHealth NCD prevention program in Pakistani secondary and higher secondary schools?
- What are the perceptions of stakeholders regarding the design and content of a school-based eHealth NCD prevention program for Pakistani secondary and higher secondary school students?

3.2. Objectives

1. To identify the barriers and facilitators in conducting a school-based eHealth NCD prevention program to improve secondary and higher secondary school students' knowledge, attitudes, and practices regarding prevention and associated risk factors of NCDs.
2. To assess stakeholders' perceptions regarding the design and content of the school-based eHealth NCD prevention program to improve the knowledge, attitudes, and practices of secondary and higher secondary school students regarding prevention and associated risk factors of NCDs.

3.3. Methods

3.3.1. Study design

This study will utilize an exploratory qualitative study design to investigate the barriers and facilitators in conducting a school-based eHealth NCD prevention program and to assess stakeholders' perceptions regarding the design and content of the program. Exploratory study design aims to gather qualitative data and gain deeper insights into a relatively new or under-researched topic. It involves exploring patterns, themes, and ideas without testing specific predictions, making it useful for studying unexplored areas and generating new research questions (59).

3.3.2. Participants

The study will focus on gathering insights and perspectives from these different participant groups to comprehensively understand the research topic.

- **Students:** The target participants will be students currently enrolled in secondary and higher secondary schools in Karachi and are in grades 9 to 12.

- **Teachers:** The study will involve teachers who have been employed in secondary and higher secondary schools in Karachi for a minimum duration of 6 months.
- **Parents:** The research will invite the participation of parents or legal guardians of students who are currently enrolled in secondary and higher secondary schools in Karachi.
- **School Administrators:** This category includes principals and vice principals of secondary and higher secondary schools in Karachi, District Education Officers, and decision-makers at Provincial Department of Education.

3.3.3. Sampling technique

Participants for FGDS and KIIs will be approached through the secondary and higher secondary school principals and administrators.

Focused group discussions:

1. ***Students***

   Two FGDs with eight participants in each group will be conducted with the secondary and higher secondary school students. The target participants will be students currently enrolled in secondary and higher Secondary Schools in Karachi and in grades 9 to 12. One FGD will be conducted male students and one FGD will be conducted with female students.

2. ***Teachers***

   Two FGDs with eight participants in each group will be conducted with the secondary and higher secondary school students.

Key informant Interviews (KIIs):

1. ***Parents***

   Key informant interviews will be conducted with parents or legal guardians of students currently enrolled in secondary and higher secondary schools. The interviews will continue until data saturation is reached, ensuring a comprehensive understanding of the parents' perspectives, experiences, and insights related to the school-based eHealth NCD prevention program.

6. ***School administrators***

   Key informant interviews will be conducted with secondary and high secondary school principals, District Education Officers (DEOs), and key decision-makers at Karachi Provincial Department of Education. The interviews will be conducted until data saturation is achieved.

3.3.4. Framework for the qualitative phases

The framework for qualitative exploration phase and qualitative explanation phase is based on an adaptation of the Technology Acceptance Model (TAM) and Task Technology Fit Model (TTFM). (60) Initially, the framework will focus on exploring users' perceptions of the program's design and content, specifically examining perceived usefulness, perceived ease of use and attitude towards use. Later, the framework will assess the experience of the end-users by considering themes of usefulness, acceptability and task-technology fit.

Usefulness is defined by the perceived satisfaction of the students in achieving their goals, encompassing the outcomes and consequences of using the program. Acceptability of the end users refers to the extent to which individuals find an eHealth app or technology system suitable, agreeable, and satisfactory for their needs, preferences, and expectations. It encompasses the user's perception of the app's relevance, and appropriateness in addressing their health concerns or needs. The task-technology fit of the digital app specifically refers to its ability to support and facilitate the specific tasks of the end-users effectively. By incorporating these dimensions, the framework aims to provide comprehensive insights into user perspectives, experiences, and perceptions, guiding the development and implementation of the school-based eHealth NCD prevention program.

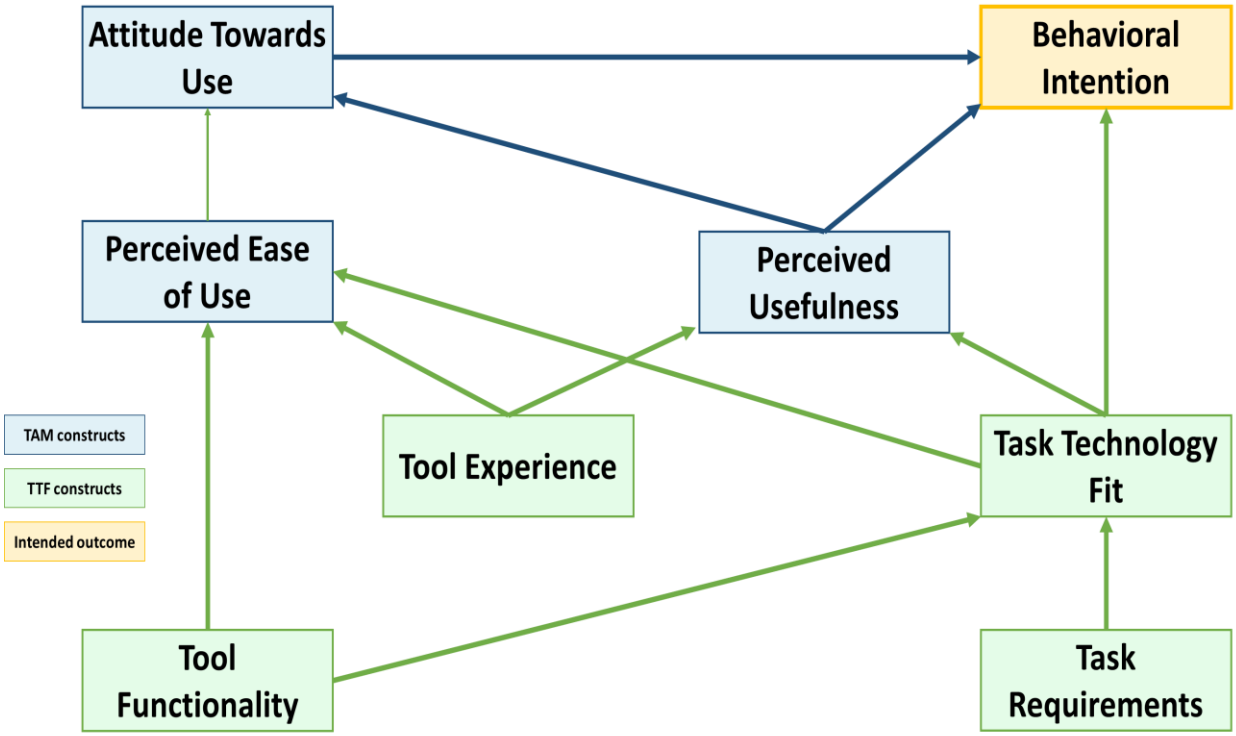

Figure 3: Integrated model of TAM and TTF

3.3.5. Data collection

Distinct semi-structured interview guides will be developed for students, teachers, parents, and administrators, incorporating the specific probes provided in table 3. These guides will be initially developed in English and subsequently translated into Urdu and Sindhi to cater to the language preferences of the participants. To ensure the effectiveness and appropriateness of the interview guides, a pre-test will be conducted, which will include one focus group discussion (FGD) and one key informant interview (KII).

The focus group discussions (FGDs) and key informant interviews (KIIs) will delve into stakeholders' perspectives regarding the barriers and facilitators associated with implementing the school-based eHealth NCD prevention program in secondary and higher secondary schools. Furthermore, the stakeholders' viewpoints on the content and design of the program will be explored. Experienced members of the core research team who possess expertise in qualitative research methods, including facilitating FGDs and conducting KIIs, will conduct the FGDs and KIIs. These members will also have a background of working in a school setting, which enhances their understanding of the context. To establish a sense of trust and rapport with the participants, informal conversations will be initiated prior to the qualitative inquiry, and the study objectives will be clearly communicated. For a summary of the data generation methods, please refer to Figure 2.

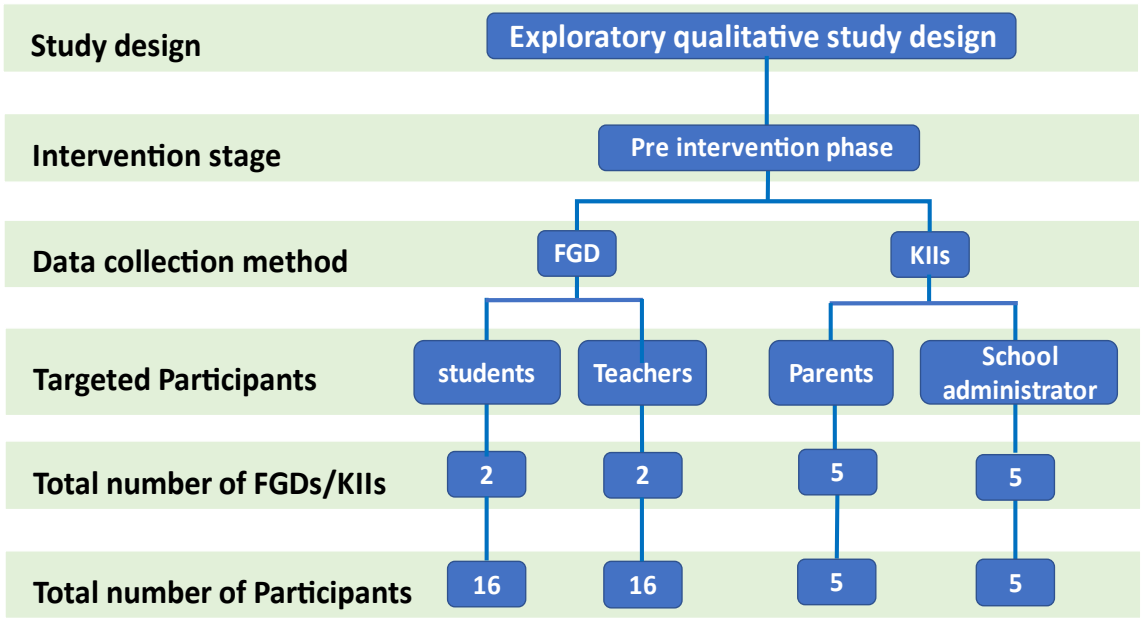

Figure 4: Summary of data collection methods- pre intervention

S. No.	Probes
1.	**Thoughts on digital applications to improve health and wellbeing of adolescents** Probe: Familiarity with digital eHealth apps, Technology acceptance , Utilization of digital eHealth apps
2.	**Opinions on incorporating health education videos into classroom sessions using multimedia** Probe: Acceptance of Multimedia Delivery, Perceived Benefits of Health Education Videos, Students' Preferences and Expectations
3.	**Relevance and applicability of the program** Probe: Views on the effectiveness and potential benefits of the program. Interest and engagement of the participants in the program.
Barriers to Implementation of the eHealth NCD Prevention Program	
4.	**Anticipated challenges in implementing the eHealth NCD prevention program in schools.** Probe: Potential difficulties and obstacles that may arise during the implementation of the eHealth NCD prevention program in educational institutions.
5.	**Cultural or social barriers.** Probe: Factors pertaining to culture or society that could hinder the successful implementation of the program.
6.	**Students' digital literacy skills** Probe: Students level of digital literacy skills. Potential difficulties or challenges in using technology
7.	**Students' motivation and sustained engagement** Probe: Challenges in terms of students' motivation and engagement in the program and strategies to overcome these challenges.
Facilitators to Implementation of the eHealth NCD Prevention Program	
8.	**Program Implementation Success Factors** Probe: Factors contributing to the successful implementation of the program. Key elements that facilitate program success and effectiveness.
9.	**Teacher and School Staff Involvement** Probe: The role of teachers and school staff in delivering the program effectively. How their participation enhances program outcomes and student experiences?
10.	**Involvement of Parents or Guardians** Probe: The potential benefits of involving parents or guardians in the program. How their participation can support students and contribute to program success?
11.	**Facilitator's Role and Challenges** Probe: The role of the facilitator in delivering the program. Challenges they may encounter during classroom sessions and strategies to address these challenges.
Content of the Health promoting videos:	
12.	**Topics to include in health education videos** Probe: Relevant topics related to diet, physical activity, and NCD prevention that should be included in the videos. Key areas of focus for comprehensive health education on NCDs prevention.
13.	**Importance of Real-Life Examples and Personal Stories** Probe: The significance of incorporating real-life examples or personal stories in the videos. How such content can enhance the relevance and impact of the health education program?
14.	**Enhancing Engagement and Effectiveness of Health Education Videos** Probe: Strategies to make health education videos more engaging and effective for students. Techniques to capture attention, maintain interest, and promote active learning.

15.	**Length and Format of videos** Probe: Suggestions for the ideal length and presentation of videos to ensure they are engaging and informative. Considerations for optimal delivery and retention of information by students.
Design of the eHealth app:	
16.	**Digital Application Features for Enhanced Learning Experience** Probe: Specific features or interactive components that would enhance students' learning experience and motivation within the digital application. Key elements that promote active participation and knowledge retention.
17.	**Designing a User-Friendly Application** Probe: Strategies to ensure ease of use for all students, including those with limited digital literacy skills. Design considerations for a user-friendly interface.
18.	**Interactive Features for Enhanced User Engagement** Probe: Types of interactive features or functionalities that should be incorporated into the application to enhance user engagement. Methods to keep students actively involved and interested in the content.
19.	**Enhancing User Experience and Program Effectiveness:** Probe: Other features or design elements that might enhance the overall user experience and effectiveness of the health education program.

Table 2: Probes for the Interview guides for students, teachers, parents and administrators.

3.3.6. Expected Outcomes

This study seeks to gain insight into the perceived barriers and facilitators in implementing a School-based eHealth NCD prevention program. Additionally, the study aims to understand stakeholders' needs and expectations regarding the eHealth program's design and content tailored for Higher Secondary School students.

3.3.7. Plan of data analysis and management

COnsolidated criteria for REporting Qualitative research (COREQ) guidelines will be used to analyze the data. Qualitative data of the study will be audio-recorded, compiled, and translated into English and then analysed using manual thematic analysis and QSR NVivo version 10 for thematic-content analysis All interviews and FGDs will be transcribed in English. Commonalities and differences across the data will be identified and clustered around thematic sections. Verbatim quotes will be added to complement the themes.

4. Quantitative Phase: Feasibility and effectiveness of a school-based eHealth NCD prevention program in improving NCDs awareness among students of Pakistani secondary and higher secondary schools.

4.1. Research question

- What is the feasibility of a school-based eHealth NCD prevention program in Pakistani secondaey and higher secondary schools?
- What is the effectiveness of a school-based eHealth NCD prevention program in improving knowledge, attitudes, and practices of Pakistani secondary and higher secondary school students?

4.2. Objectives

- To assess the feasibility of the school-based eHealth NCD prevention program in secondary and higher secondary schools in Karachi?
- To evaluate the effectiveness of the school-based eHealth NCD prevention program in significantly improving the knowledge, attitudes, and practices of secondary and higher secondary school students in Karachi, Pakistan, regarding NCDs and their associated risk factors, as compared to a control group not receiving the intervention.

4.3. Hypothesis

- The school-based eHealth NCD prevention program will demonstrate feasibility in terms of successful recruitment, retention, and treatment fidelity rates exceeding 70% among secondary and higher secondary school students in Karachi, Pakistan.
- The school-based eHealth NCD prevention program will show effectiveness in significantly improving the knowledge, attitudes, and practices of secondary and higher secondary school students in Karachi, Pakistan, regarding NCDs and their associated risk factors, as compared to a control group not receiving the intervention.

4.4. Methods

4.4.1. Study Design

The study will be conducted as a clustered randomized controlled trial (cRCT) at eight secondary and higher secondary schools in Karachi. In this design, schools will be the primary units of randomization, and the random assignment will occur at the school level. The schools will be grouped into clusters, and each cluster will be randomly assigned to either the intervention group, where the School-based eHealth NCD Prevention Program will be implemented, or the control group, which will not receive

the intervention. This clustered randomized design aims to account for potential clustering effects within schools and enhance the external validity of the study.

4.4.2. Randomization

The randomization process for the allocation of the eight selected secondary and higher secondary schools in Karachi into either the intervention or control group will involve a clustered approach to enhance the robustness of the trial.

Stratification:

The eight schools will be stratified based on their type (secondary or higher secondary) and gender (girls or boys), resulting in four strata. This ensures that the randomization process accounts for potential confounding variables associated with school type and gender.

Stratum	School Type	Gender	Number of Schools
1	Higher Secondary	1 Boys 1 Girls	2
2	Higher Secondary	1 Boys 1 Girls	2
3	Secondary	1 Boys 1 Girls	2
4	Secondary	1 Boys 1 Girls	2

Figure 5: Fours stratra - Stratification based on school type and gender

Cluster Assignment:

Each stratum, considered as a cluster, will be randomly assigned to either the intervention or control group. This helps minimize potential biases and enhances the internal validity of the study.

Randomization Sequence:

A randomization sequence will be generated using a computer-based random number generator, specifying which clusters are allocated to the intervention and control groups.

Concealed Allocation:

The allocation sequence will be concealed until the intervention begins, preventing selection bias. An independent researcher, not involved in the study implementation, will oversee the randomization process, enhancing transparency and minimizing the risk of systematic errors.

This detailed clustered randomization strategy ensures that the intervention and control groups are balanced across important characteristics, allowing for a more accurate assessment of the impact of the School-based eHealth NCD Prevention Program on the knowledge, attitudes, and

practices of Pakistani secondary and higher secondary school students, while considering potential clustering effects within schools.

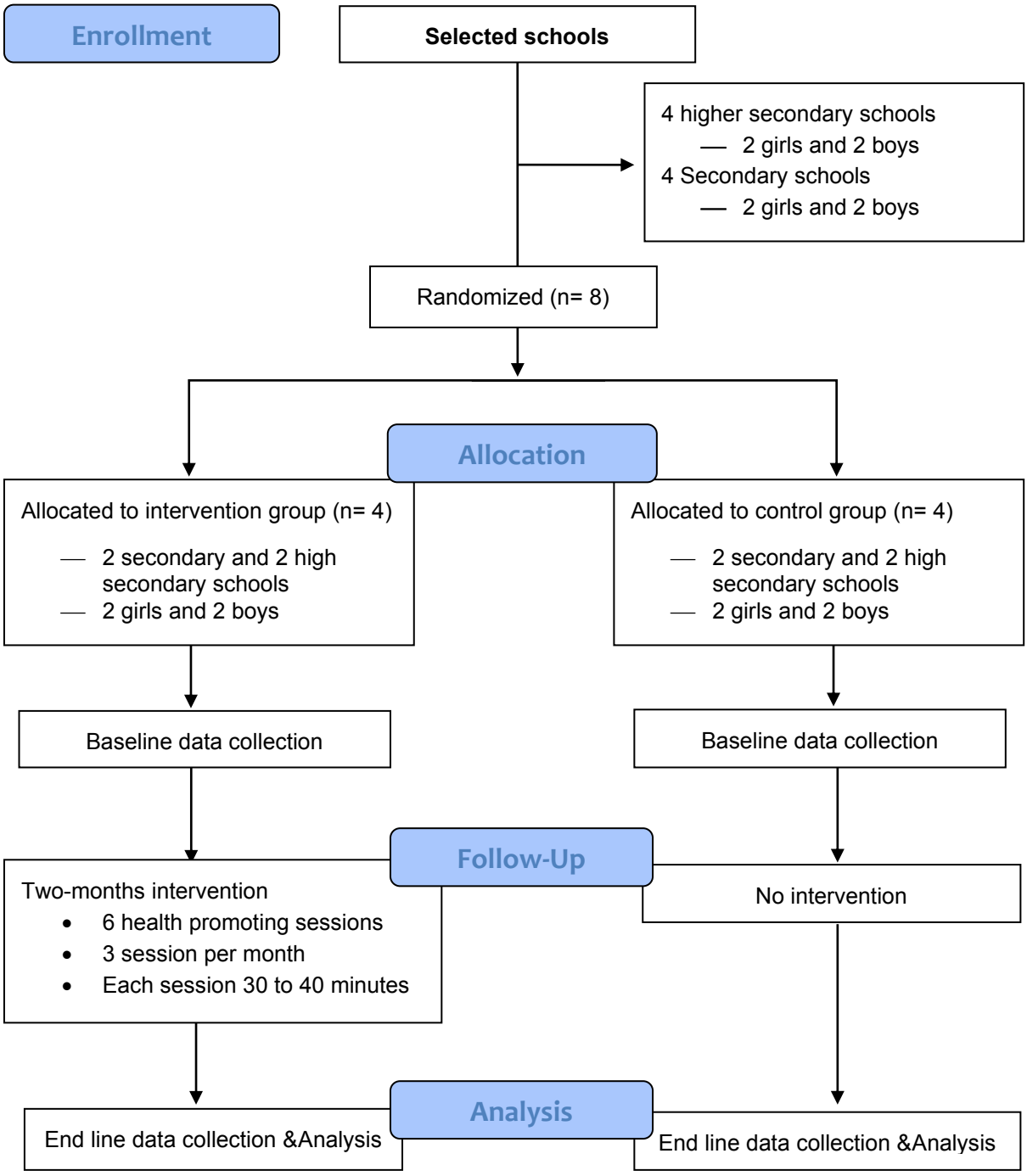

Figure 6: CONSORT flowchart for a clustered randomized controlled trial to assess the feasibility and effectiveness of the School based eHealth NCD prevention program.

4.4.3. Blinding:

Due to the nature of the School-based eHealth NCD Prevention Program intervention, blinding of participants, instructors, and researchers is not feasible in this study. The interactive and participatory aspects of the intervention, combined with the need for active engagement and awareness among both students and instructors, preclude the possibility of implementing blinding measures. Participants in the intervention group will be explicitly aware of their involvement in the program, and instructors delivering the intervention will likewise be informed. Researchers responsible for data collection and analysis will also be aware of the group assignments. While blinding is a valuable method to minimize bias, the inherent characteristics of the intervention necessitate transparency and openness in its implementation. Therefore, the study acknowledges this limitation and will employ robust methodologies, including randomization and careful data collection, to mitigate potential biases and enhance the internal validity of the results. The absence of blinding will be considered in the interpretation of findings, and efforts will be made to minimize any potential sources of bias throughout the study.

4.4.4. Participants and research setting

This study will be conducted at Secondary and Higher Secondary Schools located in Karachi, Pakistan. In Pakistan, secondary schools serve students in grades 9-10, while higher secondary schools cater to those in grades 11-12; these institutions typically accommodate students aged 13 to 18 years (32).

In the Sindh Province during the academic year 2018-2019 (61), there were a total of 1,777 secondary schools, which catered to students in grades 9 and 10, and 318 higher secondary schools, accommodating students in grades 11 and 12. In Karachi, there were 493 secondary schools and 37 higher secondary schools during the same period.

4.4.5. Intervention and Control group:

After the random allocation of schools into intervention and control groups, baseline data regarding the awareness levels of students will be collected from both groups. Allocation will be revealed to the schools after recruitment and baseline assessment to avoid recruitment bias. Students in the intervention group will participate in health-promoting sessions delivered by trained facilitators, with each session lasting 30 to 40 minutes. There will be a total of six health-promoting sessions conducted in the classroom for the intervention group, spanning two months with three sessions per month. The health-promoting videos from the School-based eHealth NCD prevention program will be shown in the classroom using multimedia.

The control group will not receive any intervention, and the endline assessment will be conducted after two months of the intervention from both the groups. However, to maintain ethical standards, one session regarding NCDs and their associated risk factors will be delivered by trained facilitators to the control group after the endline assessment.

4.4.6. School-based eHealth NCD Prevention Program

The main focus of the School-based eHealth NCD prevention program is to promote healthy behaviors among students, specifically related to diet, physical activity, and other factors associated with NCD prevention. The intervention will be delivered through a digital web-based program accessible via internet browsers, which can be utilized within the school campus if necessary. As part of this study, health education videos will be incorporated into classroom sessions using multimedia. Each session will consist of 25 to 35 students, with a trained facilitator guiding the discussions. Prior to implementing the intervention, a baseline qualitative assessment will be conducted to explore the stakeholders'perceptions regarding the content and design of the web-based program. Based on these findings, the web-based program's content and design will be refined and modified as needed.

The School-based eHealth program's conceptual framework, aimed at enhancing awareness of NCDs and associated risk factors, is rooted in the Theory of Planned Behavior (TPB) (62). The TPB explores the links between attitudes, subjective norms, perceived behavioral control, and intentions, influencing behaviors. For the web-based ieHealth program, this means that students' attitudes toward NCD prevention, societal expectations, and self-perceived control will shape their intentions and actions in adopting healthier habits. The eHealth program is designed to leverage these factors to positively influence students' knowledge, attitudes, and practices related to NCD prevention Pease refer to figure 3 for the conceptual framework of the presumed change because of this intervention.

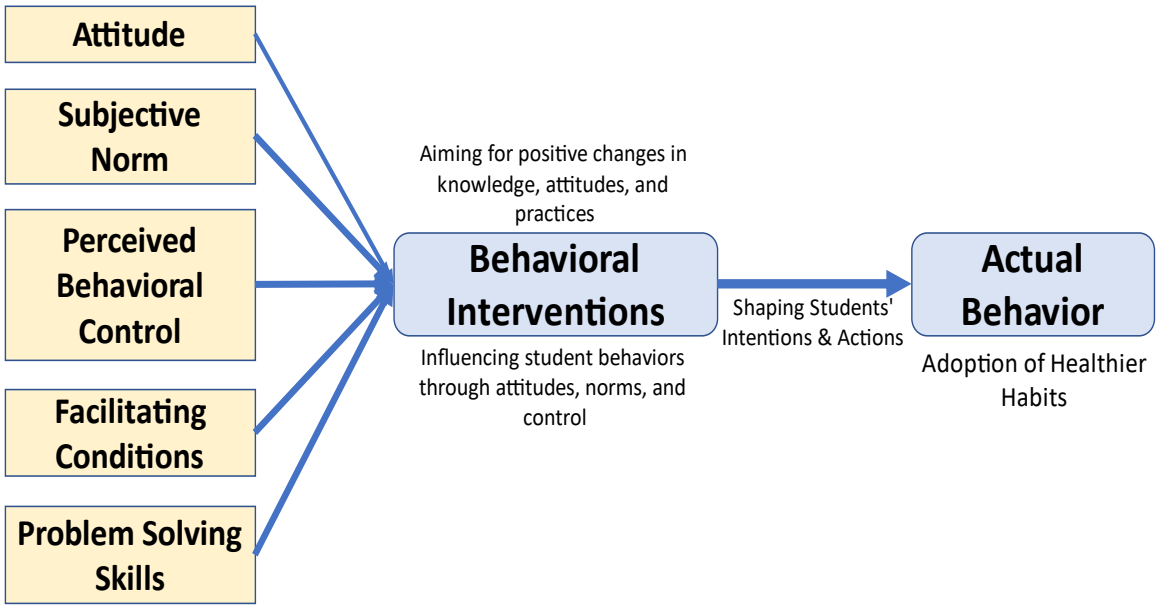

Figure 7: Conceptual framework of the eHealth app.

Features of the web-based eHealth program

The web-based eHealth program aims to support a school-based NCD prevention program for secondary and higher secondary school students. Accessible through an internet browser, the program will be operated by facilitators who will use it to show students health-promoting videos. Each user (facilitator) will have to login via their assigned username and password. There will be three segments of the web-based eHealth program, please refer to figure 2.

Figure 8: Segments of the web-based eHealth program

Pre assessment segment:

The facilitators will register participants during this segment. Data regarding the knowledge, attitude, and practices of the participants will be entered in this segment using a tool adapted

from a self-administered questionnaire. The questionnaire was originally developed to assess the knowledge, attitude, and practices of adolescents in Bangladesh concerning non-communicable diseases (NCDs) and their behavioral risk factors (63).

Health education segment:

The health education segment focuses on the facilitator's role in delivering health-promoting videos to the students. Facilitators can easily access and play the videos using the eHealth program, enhancing students' understanding and awareness of NCD prevention strategies. The health education will be developed in Urdu Language and will based on based on contextually relevant content for the Pakistani secondary and higher secondary school students of age 13 to 18 years old.

In a systematic review and meta-analysis conducted in 2019 (58), the objective was to evaluate the effectiveness of eHealth interventions implemented within school settings to address multiple lifestyle risk behaviors. The review revealed a variability in intervention structure, specifically in the duration and frequency of sessions. The observed session lengths ranged from one to 15 lessons, with timeframes spanning from 15 to 60 minutes per session. Furthermore, these interventions were administered over periods extending from a single day to as long as 36 months.

In the intervention of the current study, there will be 6 health promoting video sessions in this segment and three sessions will be delivered per month. The session will be 30 to 40 minutes and the intervention will be provided over two months. The video material will be based on six sessions, as indicated in figure 3, and the sessions' content will be planned in accordance with the format provided in table 1. The content of these six sessions will be focused on the leading risk factors associated with NCDs as reported by different studies (64, 65) such as harmful alcohol consumption, tobacco use, physical inactivity, unhealthy diet and overweight and obesity.

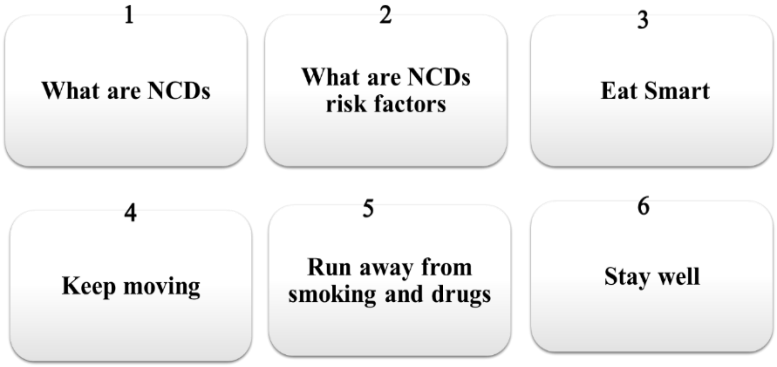

Figure 9: Proposed content of the health promoting sessions

Session Title:	Objective	Description
Session 1: What are Non-Communicable Diseases (NCDs)?	• To understand Non-Communicable Diseases (NCDs) and create awareness about their health implications.	• Definition of Non-Communicable Diseases (NCDs) • Types of NCDs (e.g., heart diseases, stroke, cancer, diabetes, etc.) • Prevalence of NCDs in Pakistan • Importance of preventing NCDs
Session 2: What are NCDs' Risk Factors?	• To identify NCD risk factors and promote healthy lifestyle choices.	• Types of risk factors (behavioral, environmental, genetic) • Common risk factors for NCDs in Pakistan (e.g., smoking, physical inactivity, unhealthy diet) • Impact of NCDs on quality of life
Session 3: Eat smart	• To discuss healthy eating habits and encourage the adoption of nutritious dietary practices.	• Importance of healthy eating for NCD prevention • Food groups and their benefits • Healthy snack options • How to make healthy food choices
Session 4: Keep moving	• To promote the importance of physical activity and exercise, and encourage individuals to engage in regular physical activity.	• Importance of physical activity for NCD prevention • Benefits of physical activity • Types of physical activity • How to incorporate physical activity into daily routine
Session 5: Run away from smoking and drugs	• To educate participants to avoid substance abuse, and prioritize overall well-being by raising awareness about the harmful effects of tobacco and drugs.	• Dangers of tobacco and drug use • Health risks associated with tobacco and drug abuse • Tips for avoiding tobacco and drug abuse
Session 6: Stay well	• To promote mental health awareness and empower participants to adopt healthy lifestyle habits for overall well-being.	• Definition of mental health • Common mental health problems • Relationship between mental health and NCDs • Techniques for managing stress (e.g., deep breathing, exercise mindfulness). • Importance of sleep for overall health

Table 3: Content of the health promoting sessions

Post assessment segment:

Following the health education segment, the eHealth program includes a post-assessment segment. Participants' data, including knowledge, attitude, and practices, will be entered again to capture any changes or improvements after the intervention. This data will then be compared with the pre-assessment data to evaluate the impact of the intervention. The results will be presented in graphs and tables, offering visual representations of the participants' progress.

4.3.7. Development of the app - User Centered Approach

To ensure the eHealth program meets the needs and expectations of the target population, it will be developed through a user-centered approach, refer to figure 6. A user-centered approach in digital app development refers to the design and development process that places the needs, preferences, and experiences of the users at the forefront. It involves understanding the target users, their goals, and their interaction with the app to create an intuitive, user-friendly product that addresses their specific needs and expectations (66).

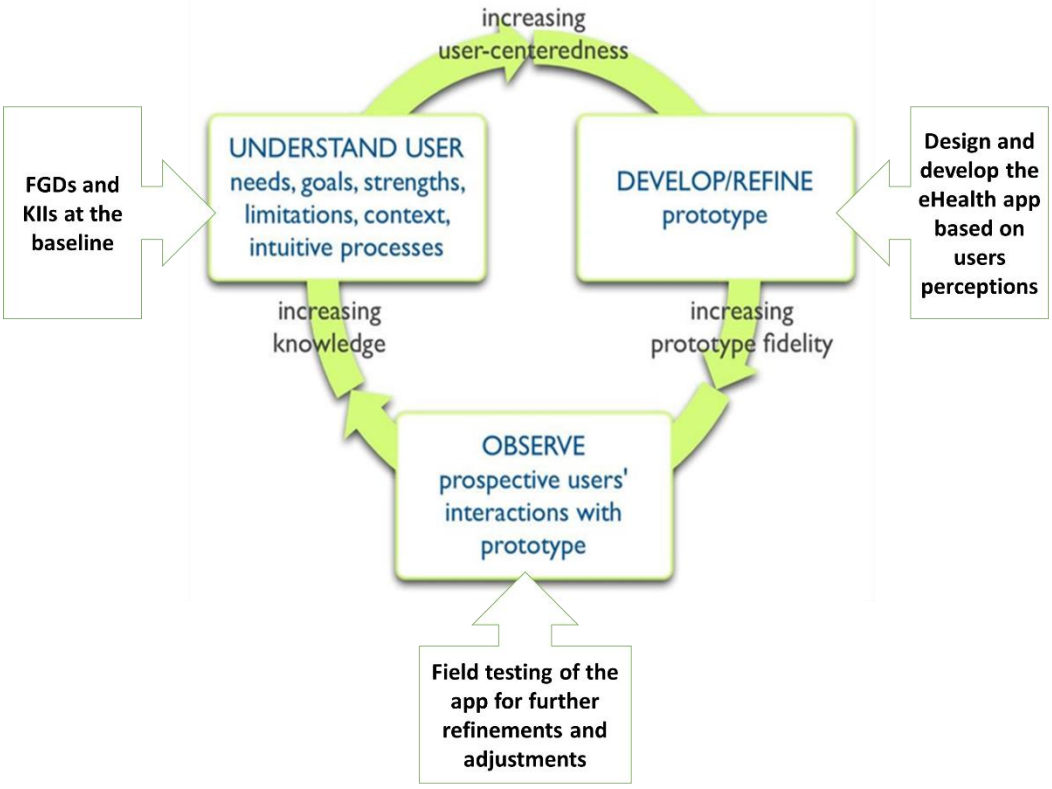

Figure 10: School based eHealth app - user centered approach

This approach involves gathering recommendations and suggestions through qualitative inquiries. Feedback from students, parents, teachers and other stakeholders will be collected and incorporated into the web based program's design and functionality. This iterative process allows for adjustments based on user needs and preferences, ensuring that the final eHealth app design aligns with user expectations and provides an optimal user experience.

Before being employed in the research intervention, the web-based eHealth program will undergo thorough testing in the field. This testing phase allows for further refinements and adjustments based on user feedback and real-world usage. It ensures that the program aligns with the specific requirements of the target population and effectively supports the objectives of the school-based NCD prevention program.

4.4.8. Workflow for delivering the intervention

The study will enroll all students in grades 9 to 12 (13 to 18 years old) from a selected secondary and higher secondary schools. A trained facilitator will log in to the eHealth program using a unique assigned ID and register the students for the intervention. The eHealth program will include a pre-installed questionnaire to gather data on the students' current knowledge, attitudes, and practices regarding NCDs.

Once registered, the students will participate in a health education session delivered through the eHealth program. The facilitator will use multimedia resources to present videos to the students while access the program's content through an internet browser. The intervention will span over 2 months, with three session per month lasting 30 to 40 minutes each.

After the 2-month intervention period, the same baseline questionnaire will be used to conduct a post-intervention survey among the participants, allowing for a comparison of their knowledge, attitudes, and practices before and after the program.

The monitoring of the school-based web-based eHealth program will be comprehensive and meticulous throughout the intervention. The intervention comprises six classroom sessions, each facilitated by a trained expert. Regular assessments of session delivery, content relevance, and participant engagement will be conducted. The facilitators will provide progress reports after each session, offering insights into students' interactions and feedback. Additionally, real-time analytics from the eHealth platform will be used to track user activity, participation rates, and completion of sessions.

4.4.9. Sample size

In conducting a clustered randomized trial, careful consideration is given to determining the optimal sample size to ensure statistical rigor and the ability to detect meaningful effects. In this study, we set out with the aim of evaluating the impact of a specific intervention across four clusters, each comprising 300 subjects (31), and accounting for an intracluster correlation coefficient (ICC) of 0.025(67). With a desired statistical power of 0.8 and a confidence interval of 0.05, coupled with an anticipated effect size of 25%, the calculated sample size was found to be 247 participants. To account for potential attrition, a prudent approach involves adding a 10% attrition rate, resulting in a revised total sample size of 272.

This calculated sample size allows for robust statistical power and confidence in detecting the expected effect size within the clustered trial. In the randomized assignment of participants, 136 individuals will be allocated to the intervention group and another 136 to the control group, totaling 272 participants

in the study. This meticulous sample size determination ensures that the study is adequately powered to discern meaningful effects and contributes to the methodological strength of the research design.

The sample size for the study was computed using JupyterHub software, accessible on Anaconda Cloud through the link: https://nb.anaconda.cloud/jupyterhub/user/d18e4bb8-b3eb-4164-a1e8-5f9a55c38458/lab/tree/sample%20size.ipynb.

4.4.10. Data collection tool

The current study will adapt a self-administered questionnaire originally developed to assess the knowledge, attitude, and practices of adolescents in Bangladesh regarding non-communicable diseases (NCDs) and their behavioral risk factors (63). The development of this questionnaire involved a comprehensive review of existing survey instruments used in the field, including the Global School Health surveys, STEPs Survey of NCD risk factors, and a Mongolian survey questionnaire.

Following the questionnaire's development, it will undergo a pre-testing phase among a comparable population. During this phase, feedback will be gathered, and necessary adjustments will be made to enhance the questionnaire's effectiveness and relevance for the study population. The questionnaire will be available in English, and Urdu Language. The questionnaire will be pre-tested among a similar population to verify the validity and reliability of the questionnaire. The finalized questionnaire will be used in both pre-intervention baseline and post-intervention end line survey.

There will be three sections in the questionnaire - the first section will contain questions on socio-demographic information of the participants. The second section will contain questions about knowledge, attitudes and practice related to NCDs e.g. cardiovascular diseases, stroke, diabetes, hypertension, etc. The third section will cover questions on knowledge, attitudes, and practice related to NCDs' behavioral risk factors e.g. diet, physical activity, and smoking.

4.4.11. Data collection procedure:

The data collection procedure will commence with obtaining permission from the pertinent authorities at the provincial and district education departments, as well as from school principals. Consent will be sought from parents, while assent will be obtained from secondary and higher secondary school students. Scheduling of data collection will be coordinated with school administrators to ensure a suitable time. Trained data collectors will be responsible for gathering data on the school premises using interview-based questionnaires. Additionally, the students' weight and height will be measuredby using calibrated weighing scales and stadiometers for accurate measurements. The procedure involves requesting participating students to stand barefoot on the weighing scale, ensuring an even distribution of weight, and recording the reading. Height measurement will be taken with the

student standing upright against the stadiometer, with heels, back, and head in contact with the device. This approach ensures the ethical and systematic acquisition of necessary information while respecting the privacy and well-being of the participants.

4.4.11. Outcome variables

Feasibility outcomes

The feasibility of a School-based eHealth NCD prevention program will be assessed regarding recruitment, retention, and treatment fidelity (68). The trial will be considered feasible if recruitment, retention, and treatment fidelity rates exceed 70% (69).

1. Recruitment will be measured as the percentage of participants enrolled out of the total number of invited participants at baseline phase.
2. Retention will be assessed as the percentage of participants available for follow-up at 3 months among those recruited initially.
3. Treatment fidelity will be defined as the proportion of planned health promoting sessions that are successfully conducted.

Effectiveness outcome

The effectiveness will be measured in terms of participants' knowledge, attitude and practices at baseline and follow up of 2 months.

Knowledge

Knowledge about NCDs and their associated risk factors will be assessed using a set of 26 questions. Each question will be scored as either correct or incorrect, based on information derived from standard medical textbooks and guidelines. The total knowledge score will be calculated, with a higher score indicating a better Knowledge of NCDs and their associated risk factors. This study's cut-off level for determining "good knowledge" will be set at a percentage score of 60% or higher. This decision is based on previous Knowledge, Attitudes, and Practices (KAP) studies where a score of 60% or above has been used to categorize participants as having a satisfactory level of knowledge. (70-72). This means that participants who achieve a score equal to or above 60% on the knowledge assessment will be considered to have a satisfactory level of knowledge regarding NCDs and their associated risk factors.

Attitude

Attitudes towards NCDs and their risk factors will be assessed using a set of 14 attitude measuring questions presented on a Likert scale. Participants will be asked to rate each item on a 3-point scale, except for one item which will be rated on a 4-point scale. The scores will be added, and higher scores in the attitude section will indicate a more positive attitude towards NCDs' prevention. The attitude section will have a possible minimum score of 16 points and a possible maximum score of 49 points. In accordance with previous studies, the cut-off value for attitude will be set at 60%. This threshold is derived from existing research where a score of 60% or higher has been identified as an indicator of a positive or favorable attitude.

Practice

Practice questions will be used to evaluate dietary habits, physical activity, smoking, and substance abuse by 22 items. This study will measure the following practices based on WHO recommendations and standard practices for adolescent age.

1. Dietary habits: presence of at least two of the following four habits will be accounted as having dietary risk behavior
    i. Inadequate fruit consumption: Less than five servings of fruit per day
    ii. Inadequate vegetable consumption: Less than five servings of vegetables per day
    iii. Excessive salt consumption: Taking extra or raw salt during every meal
    iv. Sugar Sweetened Beverage (SSB) consumption: Consuming SSB more than 3 days per week
2. Physical activity: Not meeting 60 min physical activity of moderate intensity per day will be regarded as physically inactive.
3. Smoking and alcohol: Smoking regularly in the last 30 days or exposing to passive smoking more than 3 days per week will be accounted as in risk of smoking. Any amount of alcohol intake or any substance abuse in the last 30 days will be regarded as at risk.

4.4.12. Independent variables / potential confoudunng variables

The socio-economic variables will serve as independent variables in the analysis. They provide important information about participants' demographic characteristics, family background, and household conditions. By examining the relationship between the independent variables and the dependent variables, we can gain insights into how factors such as gender, age, Body Mass Index

(BMI), parental occupations and education, family health history, household amenities, and access to a playground may impact participants' knowledge, attitude, and practices related to NCDs.

These independent variables will be treated as potential confounders and will be analyzed alongside the dependent variables to explore potential correlations and associations. The findings will contribute to understanding the influence of socio-economic factors on the participants' knowledge, attitude, and practices regarding NCDs, providing valuable insights for further research and interventions in this area.

4.4.13. Expected Outcomes

This Study is expected to assess feasibility and effectiveness of the School-based eHealth NCD prevention program in improving the knowledge, attitude, and practices of secondary and higher secondary school students regarding the NCDs and their associated risk factors such as unhealthy diet, physical inactivity, smoking etc.

4.4.14. Plan of data analysis and management

Data collected from respondents in this clustered randomized controlled trial (cRCT) will undergo a thorough analysis using appropriate methods to account for the clustered nature of the study design. The data will be exported from the Health app to Statistical Package for the Social Sciences (SPSS) Version 21 (IBM Corp), where it will be cleaned, coded, and analyzed. Raw and processed data will be securely managed on a Microsoft Excel spreadsheet.

Descriptive analysis: Descriptive analysis will involve tabulating results as numbers (percentages) for qualitative variables and mean (±standard deviation) for quantitative variables. To capture the cluster-level characteristics, summary statistics will be generated at both the individual and school levels.

Inferential analysis: Quantitative variables will be assessed for normality using the Shapiro-Wilk test. Given the clustered nature of the trial, a multilevel modeling approach, specifically linear mixed-effects models, will be employed to analyze quantitative outcomes. This approach is particularly suitable for accounting for within-cluster correlations.

The analysis will include a comparison of baseline characteristics between the intervention and control groups. Appropriate statistical tests for categorical variables, such as chi-square tests, and continuous variables, such as independent t-tests or Mann-Whitney U tests based on distributional assumptions, will be utilized. To assess the effectiveness of the intervention, before-after data will be analyzed within each group using paired t-tests. Additionally,

between-group analysis will be conducted using independent t-tests, comparing the change scores between the intervention and control groups.

Association analysis: Mixed-effects logistic regression models will be used to explore the associations between sociodemographic variables and changes in binary outcome variables (knowledge, attitude, and practice) while considering the clustering effect at the school level. Furthermore, mixed-effects linear regression models will be applied to assess the association of continuous outcome variables, such as knowledge scores and attitudes, with changes in self-reported practices. Random effects for schools will be explicitly specified to address the inherent clustering within the study design. Covariates for the multivariable analysis will be carefully chosen based on theoretical or empirical reasoning, avoiding the use of a stepwise approach to prevent overfitting and instability. Results from the analysis will be presented as adjusted odds ratios (OR) with corresponding 95% confidence intervals (CI). The significance level for all analyses will be set at 0.05, deeming any association with a p-value less than 0.05 as statistically significant.

5. Qualitative Explanation Phase: Usefulness, acceptability and task technology fitness of a school-based eHealth NCD prevention program.

5.1. Research question

- What are the perceptions of higher secondary school students regarding the usefulness, acceptability and task technology fitness of a school-based eHealth NCD prevention program?

5.2. Objective

- To explore the perceptions of secondary and higher secondary school students regarding the usefulness, acceptability, and task technology fitness of a school-based eHealth NCD prevention program in improving the knowledge, attitudes, and practices.

5.3. Methods

5.3.1. Study design

A qualitative explanatory design will be employed in this study. A qualitative explanatory design in sequential mixed methods design is a valuable approach that helps researchers provide meaningful explanations and context to quantitative findings in quantitative phase. It will enriches the overall understanding of a research problem and enhances the validity of the study's conclusions (59).

5.3.2 Study participants and Sampling Technique

The study will include participants from grades 9 to 12 of the secondary and higher secondary schools who actively participated in the intervention and attended all the health-promoting sessions. Two focus group discussions (FGDs) will be conducted with eight participants in each group. One FGD will be conducted with male students and one with female students.

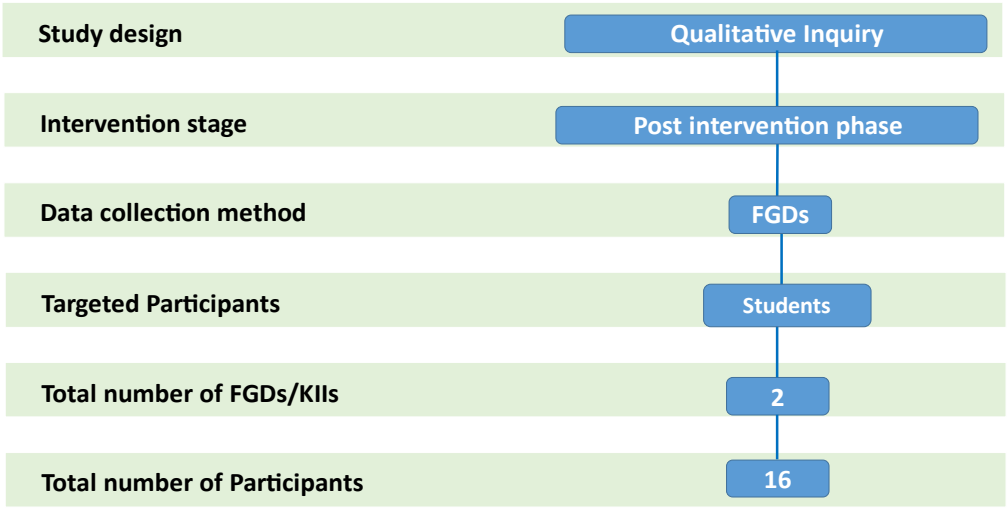

Figure 11: Summary of data collection methods- post intervention

5.3.3. Data collection tools and methods

A semi-structured interview guide will be developed in English and will be translated into Urdu and Sindhi. The FGDs will explore students' views regarding the usefulness, acceptability, and task technology fitness of a school-based eHealth NCD prevention program. FGDs will be conducted by expert research team members. Please refer to table 4 for the probes of the FGD guide.

Themes	Probes
Usefulness	• Overall perception of the program's usefulness in preventing non-communicable diseases (NCDs) among students. • Specific aspects or features of the program that are considered valuable. • How the program has contributed to improving knowledge, attitudes, and practices related to NCD prevention. • Specific examples of behavioral changes made due to the program.
Acceptability	• Students' level of acceptability towards the eHealth NCD prevention program. • Factors contributing to satisfaction or dissatisfaction with the program. • Relevance and appropriateness of the app's content and features for addressing health concerns.
Task Technology Fitness	• Alignment of the program with students' existing technology skills and abilities. • Impact of any technical issues or limitations on the overall experience. • Integration of the program into daily routines and tasks.

Limitation or Challenges	• Specific challenges or limitations faced in achieving desired program efficacy.
Recommendations for Improvement	• Suggestions and recommendations to enhance the program's efficacy in improving students' knowledge, attitudes, and practices towards NCDs and associated risk factors.
Ensuring Accessibility and Usability	• Strategies to ensure accessibility and usability of the program for all secondary and higher secondary school students, including those from disadvantaged backgrounds. • Methods to overcome potential barriers to program participation and engagement.

Table 4: Probes for interview guide

5.3.4. Expected outcomes

This Study is expected to provide information regarding the student's views about the e usefulness, acceptability, and task technology fitness of a school-based eHealth NCD prevention program. The study is expected to yield valuable insights that will contribute to improving the program's effectiveness in enhancing students' knowledge, attitudes, and practices related to NCD prevention.

5.3.5. Plan of data analysis and management

Consolidated criteria for REporting Qualitative research (COREQ) guidelines will be used to analyze the data. Qualitative data of the study will be audio-recorded, compiled, and translated into English and then will be analyzed by using manual thematic analysis and QSR NVivo version 10 for thematic-content Commonalities and differences across the data will be identified and clustered around thematic sections. Verbatim quotes will be added to complement the themes.

6. Ethical considerations

In conducting these studies, rigorous ethical principles will be upheld to ensure the well-being and rights of all participants. The following ethical considerations will be implemented across all phases:

Informed Consent: Written informed consent will be obtained from all participants, or their legal guardians in the case of minors, before their involvement in the study. Participants will be fully informed about the purpose, procedures, potential risks, and benefits of the study. They will have the opportunity to ask questions and clarify any concerns before providing consent.

Anonymity and Confidentiality: Participants' identities will remain confidential throughout the study. Personal identifiers, such as names and IP addresses, will not be collected or stored. Data will be assigned unique IDs to ensure anonymity. During analysis, all efforts will be made to prevent the identification of individual participants.

Data Security and Transmission: Data will be securely transmitted among research personnel using password-protected files and a secure network. Demographic information will be aggregated and de-identified before analysis to minimize the risk of individual identification based on responses.

Voluntary Participation: Participation in the studies will be entirely voluntary, and participants will have the right to withdraw at any stage without penalty or consequences.

Risk Mitigation: The research team anticipates minimal to no risks to study participants in all phases of the research.

Costs and Compensation: Participants will not incur any costs beyond their time for participating in the studies.

Approval from Authorities: For Study 2, written permission will be obtained from relevant school authorities and the provincial education department before conducting any research activities within educational settings.

7. Significance of the research project:

Non-communicable diseases (NCDs) pose a significant burden on global health(7), including lower middle income countries (3). In Pakistan, Unhealthy behaviors such as poor diet, physical inactivity, and smoking contribute to the rising prevalence of NCDs among schoolchildren and adolescents (14, 15, 17, 19). Addressing these risk factors through effective interventions is crucial for promoting healthier lifestyles and preventing NCDs. However, there is a lack of research on school-based eHealth interventions targeting NCD prevention in Pakistan (34), highlighting the importance of this study.

The contextual problem this research addresses is the limited availability of effective interventions that specifically target adolescents in Pakistan to improve their knowledge, attitudes, and practices regarding NCDs and their associated risk factors. Existing health education initiatives often rely on traditional methods, which may not effectively engage and empower students in adopting healthier behaviors. The utilization of eHealth interventions, such as web-based apps, mobile apps and multimedia resources, holds promise for reaching and positively influencing student's behaviors (29, 39, 41, 50, 51).

By conducting a feasibility study, this research aims to address the critical barrier of implementing School-based eHealth NCD prevention Program in Pakistani secondary and higher secondary schools. Through the identification of barriers and facilitators during the pre-intervention phase, the study will

provide valuable insights into the practical challenges that need to be addressed for successful implementation.

The research will also assess stakeholders' perceptions of the design and content of the eHealth intervention, ensuring that it aligns with the needs and preferences of the target population. This participatory approach recognizes the importance of engaging key stakeholders in the intervention development process, enhancing the likelihood of intervention acceptance and sustainability.

Once the aims of this research are achieved, prevailing knowledge, concepts, and practices will be advanced in several ways. First, the study will contribute to the evidence base on the feasibility and effectiveness of a School-based eHealth NCD prevention Program among students of secondary and higher secondary schools in Pakistan. This knowledge gap currently limits the implementation of evidence-based interventions in school settings.

Second, the research will provide insights into the effectiveness of the School-based eHealth NCD prevention Program in improving knowledge, attitudes, and practices related to NCDs and their associated risk factors. By evaluating the intervention's impact on students, the study will generate evidence on the impact of this approach in promoting behavior change and preventing NCDs.

Third, the findings of this research can inform the development of future interventions and policies focused on NCD prevention among students in Pakistan. The identification of barriers, stakeholder perceptions, and lessons learned from this study can guide the refinement and scale-up of school-based eHealth interventions in the country.

This research project addresses a critical gap in knowledge and practice by evaluating the feasibility and potential efficacy of a School-based eHealth NCD prevention Program in Pakistani secondary and higher secondary schools. By contributing evidence on the implementation, design, and impact of the intervention, this study aims to advance prevailing knowledge, concepts, and practices in the field of health education and prevention among students, ultimately promoting healthier lifestyles and reducing the burden of NCDs in Pakistan.

8. Strengths and limitations of the research project

The research project possess several strengths that will enhance its robustness. Employing a sequential mixed method design, it will generate a comprehensive understanding of the school-based eHealth NCD prevention program, bolstered by data triangulation that will enhance the credibility and reliability of findings. This integration of qualitative and quantitative data will not only validate quantitative outcomes through qualitative insights but will also situate quantitative results within a

broader context, facilitating a deeper comprehension of the factors influencing program outcomes. The employment of a clustered randomized controlled trial design enhances the project's robustness by providing a more rigorous evaluation of the school-based eHealth NCD prevention program. This design allows for better control of potential confounders, contributing to the internal validity of the study. Furthermore, the inclusion of diverse stakeholder perspectives, encompassing students, educators, parents, and other relevant stakeholders, will fortify the credibility of findings by offering a rich array of viewpoints on barriers, facilitators, and program effectiveness.

However, the research project is not without limitations. The project will contribute valuable insights to secondary and higher secondary schools in Karachi, however, its findings will have limited generalizability to other educational settings or cultural contexts. Additionally, conducting a complex mixed methods study spanning multiple phases will necessitate significant time, resources, and coordination, posing challenges to effective management. Lastly, the longitudinal nature of the pre and post design will render the project susceptible to attrition, potentially affecting the representativeness of the final sample and introducing biases into the results.

9. Research timeline:

TASKS	Q1, 2023	Q2, 2023	Q3, 2023	Q4, 2023	Q1, 2024	Q2, 2024	Q3, 2024	Q4, 2024
1. Finalization of study protocol and tools								
2. Pretesting of the tools								
2. Ethical approval								
3.eHealth app development								
4. Pre intervention assessment								
5.Intervention roll out								
6. Post intervention assessments								
7. Data analysis and manuscripts writing								

Table 5: Gantt chart of the project

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