narra j

Enhancing adolescent hypertension prevention in Indonesia through interactive multimedia: Model development and validation

Sugih Wijayati[1*], Mateus Sakundarno[1], Antono Surjoputro[1] and Budiyono Budiyono[1]

[1]Department of Public Health, Faculty of Public Health, Universitas Diponegoro, Semarang, Indonesia

*Corresponding author: sugihwijayasam@gmail.com

Abstract

Adolescent hypertension is emerging as a significant health challenge. Peer-led interventions utilizing engaging multimedia platforms have demonstrated the potential to enhance prevention behaviors among adolescents. However, there remains a gap in the literature comparing the effectiveness of multimedia intervention with traditional lecture-based approach in adolescent hypertension prevention in Indonesia. The aim of this study was to compare the traditional lecture-based approach and interactive multimedia intervention (e-module, animated videos, and infographics) on adolescents' knowledge, attitudes, and practices regarding adolescent hypertension prevention. A quasi-experimental study with pre-test and post-test control group study was conducted from June to December 2023 in two senior high schools in districts of Pedurungan and Kedungmundu, Semarang, Central Java, Indonesia. To prepare the multimedia model, the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) framework and mapping intervention approach were employed to ensure effective decision-making at each step. A total of 100 high school students were involved, with 50 assigned to the intervention group and 50 to the control group. The intervention group received a multimedia model from the peer educators, while the control group received a traditional PowerPoint-based presentation from the community healthcare workers. The hypertension prevention knowledge, attitude, and practice were assessed using validated questionnaires with 20, 15, and 15 items, respectively. This study found that, after model implementation, significant improvements were observed in students' knowledge, attitudes, and practices regarding hypertension prevention (all had $p<0.001$). Specifically, knowledge scores increased by 4.78 points, attitude scores by 10.64 points, and practice scores by 2.9 points. This study highlights that multimedia interventions could significantly improve hypertension prevention behaviors among adolescents by enhancing their knowledge, attitudes, and practices through engaging and interactive multimedia materials.

Keywords: Animated video, module, infographic, hypertension, adolescent

Introduction

Adolescent hypertension is an emerging significant health challenge globally [1]. While prevalence rates vary, ranging from 1–2% in developed countries to 4.8–10% in developing countries, the concern is particularly pertinent in Indonesia [2,3]. The prevalence of adolescent

hypertension in Indonesia has been on the rise, with rates escalating from 5.7% in 2013 to 7.2% in 2018 [4]. In the province of Central Java, Indonesia, the prevalence stands at 2.5%, with the city of Semarang slightly higher at 3.2% [2]. This surge in adolescent hypertension is largely attributed to unhealthy lifestyles, including poor dietary habits, insufficient physical activity, and risky behaviors such as smoking and alcohol consumption [5-7].

Implications of adolescent hypertension extend beyond immediate health concerns, as it significantly elevates the risk of cardiovascular diseases in adulthood [8]. Addressing adolescent hypertension requires a comprehensive understanding of the risk factors involved, emphasizing the importance of effective interventions aimed at mitigating long-term health risks [9]. Despite the growing prevalence of adolescent hypertension, access to reliable health material and health services remains limited [10]. Adolescents often rely on informal sources such as peers, parents, teachers, or healthcare workers for guidance, highlighting the need for targeted interventions to promote preventive behaviors [11,12].

Professional support is recognized as an effective prevention for adolescent hypertension, yet constrained by limitations in time and resources [12,13]. Empowering adolescents through peer-led interventions utilizing engaging multimedia platforms has shown promise in improving prevention behaviors [14,15]. However, there remains a gap in the literature comparing the effectiveness of multimedia interventions with traditional lecture-based approaches in adolescent hypertension prevention in Indonesia [16]. The aim of this study was to compare the traditional lecture-based approach and interactive multimedia intervention (e-module, animated videos, and infographics) on adolescents' knowledge, attitudes, and practices regarding hypertension prevention.

Methods

Study context
The efforts of the Indonesian Ministry of Health to promote adolescent health behaviors have faced challenges in Semarang [17,18]. Despite guidelines and technical instructions, the delivery of adolescent hypertension prevention material remains suboptimal, resulting in low prevention behaviors [19]. Semarang was chosen as the study site due to preliminary findings indicating increased cases of adolescent hypertension and a high prevalence of unhealthy lifestyle behaviors [19,20].Additionally, Semarang's Health Department report highlighted the absence of adolescent hypertension prevention programs for high school students [21]. Senior high schools were chosen as the study population because of their potential to reach adolescents early for hypertension prevention through peer groups and extended interaction times.

To prepare and assess the effectiveness of the multimedia model on hypertension prevention, the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) framework and mapping intervention approach were employed to ensure effective decision-making at each step. Each stage of the preliminary and actual study is detailed in **Figure 1**.

Preliminary study
The preliminary study was conducted in May 2023 to have initial data on adolescent hypertension prevention behaviors among high school students. The questionnaire included inquiries on demographics such as gender and age, as well as the perception of knowledge about adolescent hypertension, habits related to balanced diet consumption and regular physical exercise, adequate sleep of at least eight hours per day, access to information about adolescent hypertension, perception on adolescent hypertension as a serious health issue, availability of time to reach the nearest healthcare facility, and levels of social support for maintaining a healthy lifestyle.

In addition, this study also assessed the validity and reliability of the questionnaire among 30 students from a senior high school in Semarang, distinct from the 70 students mentioned earlier, all of whom were from different high schools than those in the intervention or control groups of the study. The validity test utilized Pearson product-moment correlation, where an r value exceeding the table r was considered valid. The reliability test calculated Cronbach's alpha, with a value greater than 0.6 considered reliable.

1 Preliminary study

Time
May 2023

Objective
To understand the characteristics of adolescent hypertension prevention behavior

Method
A questionnaire was distributed online via Google Form targeted senior high school students in Semarang, Central Java, Indonesia, none of whom were part of the intervention or control groups

2 Need analysis

Time
June 2023

Objective
To assess student's prior knowledge, school policies, and existing programs for integration

Method
In-depth interview and focus group discussion was conducted with senior high school students, school headmaster, teachers, peer educators, community healthcare workers, and Semarang Health Department staff

4 Implementation

Time
August - December 2023

Objective
To assess the impact of adolescents hypertension prevention multimedia model on knowledge, attitude, and practice

Method
A quasi-experimental pretest and posttest control group design

Groups
50 students as intervention group and 50 students as control group

Key activities
- Recruiting and training peer educators
- Intervention group: Peer educators deliver a six-week intervention via WhatsApp group with e-module, animated videos, and infographics
- Control group: Community healthcare workers deliver a series of traditional PowerPoint-based lectures over six weeks
- Both intervention and control groups underwent pretest and posttests before and after model implementation

3 Design and development

Time
July 2023

Objective
To draft and validate initial model (infographics, animated videos, and e-module) with experts, healthcare workers, teachers, and students

Method
Qualitative feedback from experts and quantitative data through a 5-point Likert scale

5 Evaluation

Time
August - December 2023

Objective
To assess the impact of adolescents hypertension prevention multimedia model on knowledge, attitude, and practice

Method
Pretest conducted at the first week of model implementation, followed by posttests at second and sixth weeks.
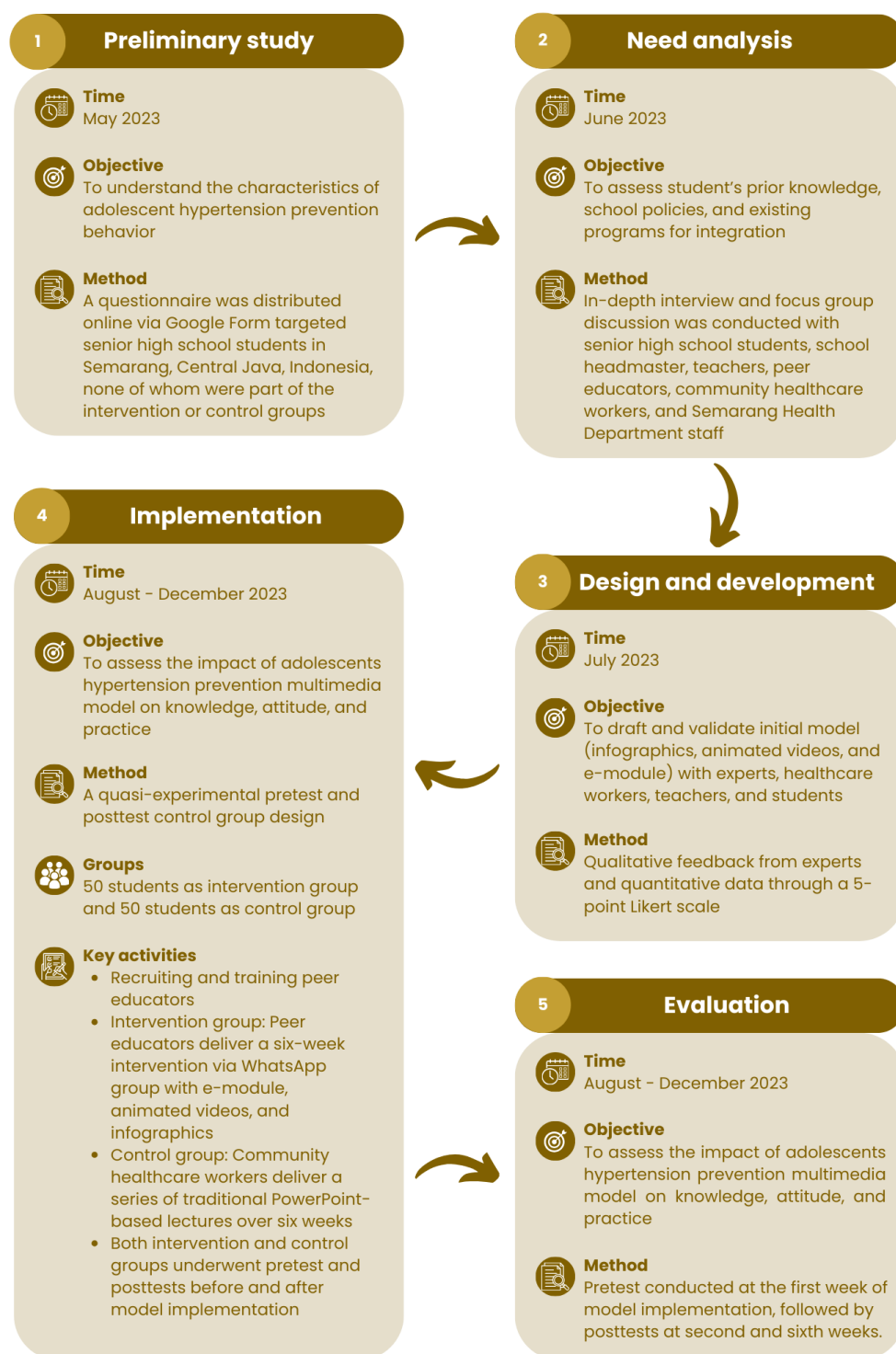
Figure 1. Overall study flowchart starting from preliminary study, need analysis, design and development, implementation of the program and evaluation of the program.

Model of the needs analysis

In June 2023, a needs analysis was conducted at the Semarang Health Department Office, a community healthcare center and two senior high schools in Pedurungan and Kedungmundu districts of Semarang. The objectives were to evaluate students' prior knowledge of adolescent hypertension, review school policies, and assess existing school programs regarding adolescent hypertension for potential integration. Data collection methods included in-depth interviews and focus group discussions (FGD).

The concept of the needs analysis involved thoroughly examining and understanding what students require regarding the adolescent hypertension prevention model, encompassing:

material delivery strategies, content materials, material presenters, duration and frequency of material delivery, and media for delivering hypertension prevention material. The needs analysis also assessed student's prior knowledge about adolescent hypertension prevention, including definitions, signs and symptoms, risk factors, and complications, as well as habits related to balanced diet consumption, adequate rest, and stress management. Moreover, we delved into the current challenges faced by various stakeholders involved in adolescent hypertension prevention and investigated the forms of support that stakeholders could provide, ranging from financial resources to collaborative efforts. Additionally, stakeholders offered valuable suggestions for the design and development of the model.

The in-depth interview and FGD were conducted with senior high school students, the school headmaster, teachers, peer educators, community healthcare workers, and Semarang Health Department staff. Purposive sampling was utilized as a sampling technique. Thematic analysis was employed for data analysis using an inductive process to identify the main themes, which guided the subsequent model design and development.

Model design and development

Based on the needs analysis, an initial model was drafted and validated in July 2023 through a workshop with stakeholders and experts, producing one e-module, seven animated videos, and 55 infographics. The initial model was drafted based on health promotion theory and blended learning principles. The development and validation process involved several key steps: setting behavioral change objectives based on findings during the needs analysis, encompassing strategies for delivering materials and prior knowledge about preventing adolescent hypertension, as well as addressing challenges and support identified by stakeholders; identifying necessary resources, such as community healthcare workers, peer educators, teachers, and relevant stakeholders; and selecting implementation methods and strategies, including stakeholder meetings and peer-educator training.

The initial model (e-module, animated videos, and infographics) underwent small- and large-scale testing, expert validation, and revisions before the model implementation. Initial model validation and assessment were conducted by five experts with education ranging from bachelor's to doctoral degrees, including subject matter experts, multimedia specialists, healthcare practitioners, and adolescent psychologists. Two subject matter experts had bachelor's and doctoral degrees in health promotion, and two multimedia specialists had bachelor's and master's degrees in art. Additionally, one adolescent psychologist had a master's degree in educational psychology.

Initial field testing gathered qualitative feedback from health promotion experts, multimedia specialists, and 10 senior high school students via WhatsApp, leading to draft revisions. Expert evaluations focused on the perceived adequacy and suitability of model components. The main field tests included Alpha testing with health promotion experts, healthcare practitioners, and Semarang Health Department staff, as well as Beta testing with 30 senior high school students, providing quantitative data using a 5-point Likert scale questionnaire regarding model material.

Alpha testing evaluated material quality, interface, content, and reliability, while Beta testing assessed motivation, presentation, comprehension, and user impact. The 5-point Likert scale was classified as follows: strongly agree (5 points), agree (4 points), neutral (3 points), disagree (2 points), and strongly disagree (1 point). The overall score was calculated by summing individual responses and then converting the total to a percentage. Scores ranging from 76% to 100% were considered satisfactory.

Model implementation and evaluation

Study design and setting

The model implementation and evaluation were conducted in a quasi-experimental study. The quasi-experimental with pre-test and post-test control group study was conducted from August to December 2023 in two senior high schools in districts of Pedurungan and Kedungmundu, Semarang, Central Java, Indonesia. The adolescent hypertension prevention multimedia model was created, including one e-module, seven animated videos, and 55 infographics, covering adolescent hypertension and preventive behaviors such as routine blood pressure checks,

smoking cessation, regular physical exercise, balanced diet consumption, adequate rest, and stress management.

A total of 100 high school students were involved, with 50 students from a high school in Pedurungan as the intervention group and 50 students from a high school in Kedungmundu as the control group. The intervention group received a multimedia model by peer educators, while the control group received a traditional PowerPoint-based presentation by community healthcare workers. The effectiveness of the hypertension prevention multimedia model was evaluated using pre-tests and post-tests to measure the knowledge, attitudes, and practices of both groups before and after the model was implemented.

Sampling strategy and participants

To calculate the minimum sample size, the delta value (Δ) based on the effect proportion and standard effect of the intervention was determined using the Lameshow formula, employing an analytical calculation with a cross-sectional approach. An absolute error of 5% was utilized. The target population comprised all 700 high school students in the 10th grade from two high schools. The calculations indicated a minimum sample size of 48 for each group was required.

A stratified random sampling technique was used, with stratification by class. Each high school had ten classes with 35 students per class, and five students were randomly selected from each class to ensure representation across all classes in both schools. Sample group allocation was conducted using a simple randomization technique implemented through Microsoft Excel v.2020 (Microsoft, Redmond, Washington, USA). The study included 10th-grade high school students with smartphones who were capable of using them and remained in the same location during the study period. Students with hypertension or without smartphones were excluded from the study.

Intervention

Peer educators from senior high school students within the age range of 15–18 years old, with good health knowledge and communication skills, were recruited and trained. After receiving training, peer educators provided health education to intervention groups in their respective groups, with 10 WhatsApp groups formed, each consisting of five students. Peer educators delivered a six-week intervention via WhatsApp group. The material was delivered daily between 4 PM and 8 PM, with each group in the WhatsApp group agreeing upon the specific time. Material delivery was conducted for 60 minutes daily over a six-week intervention period. If there were no questions regarding the material, the discussions in the WhatsApp group could be concluded earlier. Material delivery and subsequent discussions or questions and answers (Q&A) sessions in these groups were monitored by the investigator and school teachers. Discussions within these WhatsApp groups were facilitated by school teachers. To ensure smooth material delivery, each group established agreed-upon rules. School teachers and peer educators were conditioned to remain active and deliver materials consistently.

For the first week of the intervention group, the schedule commenced with a pre-test on day one, followed by module-based content the subsequent day and animated videos throughout the following four days focusing on knowledge about adolescent hypertension and prevention behaviors, including routine blood pressure checks and smoking cessation. Weekly reviews of all covered materials were conducted each Sunday. During the second week, animated videos addressed balanced diet consumption and stress management alongside infographics detailing knowledge about adolescent hypertension and preventive behaviors such as routine blood pressure checks, smoking cessation, and regular physical exercise. The first post-test was administered during this week. In the third week, the focus shifted to e-module content, animated videos discussing adolescent hypertension prevention behaviors in general and preventive behaviors such as routine blood pressure checks, and infographics highlighting prevention through balanced diet consumption and adequate rest. The fourth week involved animated videos covering smoking cessation, regular physical exercise, balanced diet consumption, stress management, and corresponding infographics outlining adolescent hypertension prevention behaviors in general and preventive behaviors such as routine blood pressure checks. The fifth week incorporated e-module content and infographics focusing on smoking cessation, regular physical exercise, balanced diet consumption, and adequate rest. Finally, the sixth week concluded with the second post-test.

For the control group, community healthcare workers conducted a series of traditional PowerPoint-based lectures over six weeks face-to-face. A pre-test was administered in the first week to assess baseline knowledge. The first week covered the definition, risk factors, symptoms, and complications of adolescent hypertension. The second week addressed adolescent hypertension prevention strategies and included the first post-test. There were no activities conducted from the third to the fifth week. A second post-test was administered in the sixth week.

Study variables and instruments

The primary outcomes consisted of adolescent hypertension prevention knowledge, attitude, and practice. Four questionnaires were constructed and derived from educational material by the Indonesian Minister of Health regarding hypertension prevention [22].The questionnaires included 59 items across four questionnaires: sociodemographic data (nine items), hypertension prevention knowledge (20 items), attitude (15 items), and practices (15 items). The sociodemographic questionnaire collected age, sex, parents' occupations and monthly incomes, school infrastructure, and school policy on adolescent hypertension prevention.

To assess students' knowledge of preventing adolescent hypertension, the present study focused on two primary areas: (a) understanding adolescent hypertension, including its definition, risk factors, symptoms, and complications; and (b) knowledge of preventive behaviors. Knowledge of preventive behaviors emphasized regular blood pressure checks at healthcare facilities, cessation of smoking through complete avoidance, engaging in regular physical exercise such as brisk walking for under 30 minutes daily or walking 3 km, managing weight through sufficient physical exercise and reduced consumption of high-calorie foods to prevent overweight, and adopting a balanced diet that limits sugar, salt, and high-fat foods while abstaining from alcohol. Adequate rest, defined as 7–8 hours of nightly sleep, and effective stress management were also assessed. The attitude and practice questionnaires focused on adolescent hypertension preventive behaviors similar to the knowledge questionnaire, with each item adjusted slightly by paraphrasing into verb-form sentences.

The knowledge questionnaire had true/false questions, with true answers scoring as 1 and false as 0. The attitude questionnaire used a 3-point Likert scale (agree=1, undecided=0, disagree=0). The practice questionnaire had yes/no questions, with yes scored as 1 and no as 0. The overall score was the sum of individual item scores.

Statistical analysis

Continuous data were presented as mean and standard deviation, while categorical data were presented as percentages. The assumption of data homogeneity was evaluated using Mauchly's Test of Sphericity. In cases where the data were not homogeneous, the *p*-value from the Greenhouse-Geisser correction was used. The univariate analysis assessed differences in adolescents' knowledge, attitudes, and practices before and after model implementation in both intervention and control groups, including the Chi-squared test, Fisher's exact test, independent t-test, and Mann-Whitney, depending on data type and data normality distribution. Data analysis was conducted using SPSS v.26.0 software (IBM, New York, USA), with *p*<0.05 was considered statistically significant.

Results

Preliminary study

Out of the total respondents included in the preliminary study, more than half of the students were female (57.1%) and under 17 years old (58.6%) (**Table 1**). A majority perceived limited knowledge about adolescent hypertension (62.9%) and did not consider it a serious issue (30.0%). Additionally, many lacked regular habits of balanced diet consumption (47.0%) or regular physical exercise (74.3%). Most students reported inadequate sleep with less than 8 hours per day (58.6%) and access to information about adolescent hypertension was limited (80.0%). Time constraints (80.0%) and insufficient social support (62.3%) hindered access to healthcare and healthy lifestyle adoption (**Table 1**). The reliability tests indicated that the questionnaires were valid and reliable.

Table 1. Students' characteristics and findings from the preliminary study (n=70)

Variables	Frequency (%)
Sex	
Male	30 (42.9)
Female	40 (57.1)
Age	
<17 years	41 (58.6)
≥17 years	29 (41.4)
Perception of knowledge about adolescent hypertension	
High	26 (37.1)
Low	44 (62.9)
Has a habit of balanced diet consumption	
Yes	37 (53.0)
No	33 (47.0)
Has a habit of regular physical exercise	
Yes	18 (25.7)
No	52 (74.3)
Sleeping habit	
<8 hours/day	34 (58.6)
≥8 hours/day	24 (41.4)
Have access to information about adolescent hypertension	
Yes	14 (20.0)
No	56 (80.0)
Perception of adolescent hypertension	
Dangerous	21 (30.0)
Not dangerous	49 (70.0)
Time availability to the nearest healthcare facility	
Yes	14 (20.0)
No	56 (80.0)
Social support for a healthy lifestyle	
Good	27 (37.7)
Not good	43 (62.3)

Model of the needs analysis

Semi-structured interviews with senior high school students revealed two main themes: strategies for delivering adolescent hypertension prevention materials and prior knowledge about adolescent hypertension prevention (**Table 2**). Students preferred interactive, tailored content delivered via social media due to limited time and knowledge about adolescent hypertension. Students favored professional and relatable presenters, preferably peers. Brief and regular material delivery using platforms such as WhatsApp and Instagram was preferred, employing interactive formats such as animated videos and infographics.

Table 2. Results from in-depth interviews conducted with senior high school students to assess the needs analysis

Main theme	Subtheme	Results
Material delivery strategies of adolescent hypertension prevention	Types and methods of material delivery for hypertension prevention	Students desire engaging and tailored content delivered through interactive and two-way methods
	Challenges in delivering hypertension prevention material	Most students stated that they have limited knowledge about adolescent hypertension, primarily due to a lack of free time
	Hypertension prevention delivery materials	Students need adolescent hypertension prevention materials that are accessible via social media, concise, clear, incremental, and easy to understand
	Hypertension prevention material presenters	Students prefer presenters who are professional, youthful, and interactive, with peer presenters being particularly popular
	Duration and frequency of hypertension prevention material delivery	Students prefer the duration and frequency of material delivery should be brief yet regular and consistent, ideally occurring more than once

Main theme	Subtheme	Results
	Media for delivering hypertension prevention material	Students prefer interactive media such as animated videos, infographics, or infographics accessible via apps such as WhatsApp, Instagram, or other social platforms
Prior knowledge about adolescent hypertension prevention	Definition, signs and symptoms, risk factors, and complications of adolescent hypertension	Students mistakenly believe hypertension primarily affects older individuals, leading them to overlook their own health. Yet, most lack awareness of hypertension in their age group
	Balance diet consumption	Students prefer fast food/junk food over vegetables and fruits due to convenience and taste. They lack regularity in consuming nutritious foods and have limited understanding of nutrition
	Adequate rest	Students believe they lack sufficient rest due to extracurricular activities, late-night studying, and excessive gadget use. They have a limited understanding of the importance of rest
	Managing stress properly	Students have a limited understanding of the importance of and strategies for effectively managing stress while maintaining good mental health

Students mistakenly believed hypertension affects only older individuals, leading to neglect of their health. They preferred fast food over nutritious options, lacked regular healthy eating habits, and had limited nutritional knowledge. They also suffered from insufficient rest due to extracurriculars, late-night studying, and excessive gadget use, with little understanding of the importance of rest. Furthermore, they have limited knowledge of stress management and maintaining mental health.

The implementation of the adolescent hypertension prevention multimedia model was recommended to tailor to the needs and target audience (**Table 3**). Furthermore, schools need to be self-reliant in delivering material and not rely solely on community health centers, enabling continuous dissemination of adolescent hypertension prevention through training for school health teachers, Red Cross teachers, physical education teachers, and school peer educators. During FGD, teachers and peer educators welcomed the implementation of adolescent hypertension prevention multimedia model in schools, expressing readiness to participate in training and organizing adolescent hypertension prevention multimedia model dissemination, including incorporating adolescent hypertension prevention programs into extracurricular activities and posting multimedia model on school's social media platform, such as Instagram.

Table 3. Findings from focus group discussion with stakeholders

Respondent	Challenge	Support	Suggestion
School headmaster	Time constraints	Collaboration has been established with the community health center, and activity funds are sourced from the school	Material delivery about adolescent hypertension should be conducted regularly
Physical education teacher	Visits by community health workers are irregular and periodic	Educational sessions have been conducted with teachers, but there has not been any training yet, and not everyone has participated	The school has not yet achieved self-sufficiency and sustainability in disseminating material about adolescent hypertension prevention behaviors; thus, this message needs to be communicated to the entire school community

Respondent	Challenge	Support	Suggestion
School health teachers	The school health unit has not been regularly conducting adolescent hypertension prevention activities	There has not been any collaboration with the community health center yet	The school needs to collaborate to build synergy with the health department, community health center, and parents so that health education can be sustainable
Red cross teachers	Red Cross extracurricular activities have not yet provided education on adolescent hypertension	There has not been any collaboration with the community health center yet	The school needs to become self-reliant by incorporating modern methods that meet students' expectations, such as integrating adolescent hypertension prevention programs into the school website for the Red Cross extracurricular activities
Peer educators and students	Teachers and healthcare personnel do not regularly provide education on adolescent hypertension prevention	Students have mobile phones and internet access	Education and counseling on adolescent hypertension prevention can be conducted both online and offline
Semarang health department	There is currently no specific program related to adolescent hypertension prevention in schools	Initiate a Memorandum of Understanding (MoU) with the relevant department	Community health has initiated collaboration with schools for an adolescent hypertension prevention campaign
Community healthcare workers	Not all community healthcare workers have received specific training on adolescent hypertension, and the methods of socialization are still general. Screening frequency at the health center is only once a year.	Community health workers are participating in a new program from the health department related to counseling methods, designing a regular adolescent hypertension prevention program, and building partnerships.	Socialization and training on adolescent hypertension and engaging counseling methods through social media, along with establishing an MoU with the relevant department.

Model design and development

Needs analysis found inadequate knowledge among students regarding hypertension prevention behaviors among adolescents. Material for promoting adolescent hypertension prevention in schools is sourced from adolescent hypertension health promotion guidelines crafted by the Indonesian Health Ministry. Infographics provided material on adolescent hypertension prevention behaviors, including text and images highlighting routine blood pressure checks, smoking cessation, regular physical exercise, balanced diet consumption, adequate rest, and stress management. Developed with assistance from a multimedia team, these infographics aimed to enrich educational content and train adolescents in hypertension prevention.

Delivering material on adolescent hypertension prevention behaviors in this study involved creating animated videos. These videos were produced with assistance from multimedia experts and tailored to suit the needs of students. Animated videos aimed to serve as educational materials for peer educators or teachers to train adolescents in preventing hypertension. Consisting of seven titles related to adolescent hypertension, animated videos cover topics such as measuring blood pressure, routine blood pressure checks, smoking cessation, regular physical exercise, balanced diet, adequate rest, and stress management.

E-module serves as the foundation for the implementation of material delivery activities in schools carried out by peer educators and school teachers who have undergone specific training, guidance, and supervision to conduct adolescent hypertension prevention multimedia model. Material was sourced from adolescent hypertension health promotion guidelines crafted by the Indonesian Health Ministry, including material on the definition, signs, symptoms, causes, complications, and prevention of adolescent hypertension. Additionally, it included a teaching agenda and standard operational procedures related to model implementation, along with several short questions and answers regarding adolescent hypertension. The e-module was systematically organized with clear instructions covering content, methods, and evaluation to achieve the expected outcomes.

Field testing of infographics, animated videos, and e-module with five subject matter experts yielded qualitative data in the form of improvements and suggestions as follows: (1) writing: content consistency and word typo; (2) figure color quality and layout; and (3) video audio quality, volume, and synchronization with animation. Following revisions, infographics, animated videos, and e-modules were tested in the main field. The main field testing involved an Alpha test with five subject matter experts and a Beta test with 30 senior high school students, yielding the following data: Alpha test for material, interface, readability, and reliability yielded an average score of 87.5%, while Beta test results for motivation, appearance, understanding, and utilization averaged 85%. Therefore, both Alpha and Beta testing yielded satisfactory results.

Model implementation and evaluation

Characteristics of the participants

A total of 100 senior high school students were included in this study, as presented in **Table 4**. The intervention group comprised of 36% males while the control group had 54% males. Our data suggested that demographic factors such as sex and age were similar (**Table 4**). There were significant differences in socioeconomic factors between group such as fathers' occupations ($p=0.028$) and income ($p=0.032$), mothers' occupation ($p=0.012$) and income ($p=0.015$). More mothers in the control group were self-employed and those in the intervention group had higher incomes. Nevertheless, the prior knowledge on adolescent hypertension prevention ($p=0.537$), the school infrastructure ($p=0.647$), and school policy related to adolescent hypertension prevention group ($p=0.796$) were not significant between groups. Four out of nine characteristics had a $p>0.05$, suggesting that the intervention and control groups had homogeneous characteristics except for parent's occupation and parent's monthly income (**Table 4**).

Table 4. Characteristics of the high school students (n=100)

Student's characteristics	Groups		*p*-value
	Intervention, n (%)	Control, n (%)	
Sex			
Male	18 (36)	27 (54)	0.083
Female	32 (54)	23 (46)	
Age group			0.224
15 years	0 (0)	2 (4)	
16 years	41 (82)	41 (82)	
17 years	7 (14)	7 (14)	
18 years	2 (4,0)	0 (0)	
Father's occupation			0.028
Self-employed	23 (46)	23 (46)	
Private sector employee	20 (40)	20 (40)	
State sector employee	7 (14)	7 (14)	
Father's monthly income (IDR)			0.032
<2,810,025	15 (30)	20 (40)	
≥2,810,025	35 (70)	30 (60)	
Mother's occupation			0.012
Self-employed	23 (46)	37 (74)	
Private sector employee	20 (40)	9 (18)	
State sector employee	7 (14)	4 (8)	
Mother's monthly income (IDR)			0.015
<3,065,025	24 (48)	35 (70)	
≥3,065,025	26 (52)	15 (30)	
Prior knowledge of hypertension prevention			0.537
Yes	28 (56)	15 (30)	
No	22 (44)	35 (70)	
School infrastructure			0.647
Yes	44 (88)	29 (58)	
No	6 (12)	21 (42)	
School policy on hypertension prevention			0.796
Yes	36 (72)	13 (26)	
No	14 (28)	37 (74)	

IDR: Indonesian Rupiah

Impact of model implementation on knowledge, attitude, and practice of adolescent hypertension prevention

The intervention implementation through the provision of materials via animated videos, e-modules, and infographics in each group received a positive response from the respondents. Respondents showed good enthusiasm towards the intervention, as evidenced by the numerous feedback received after the materials were provided. The discussions in the WhatsApp groups were engaging and insightful. Despite the planned 60-minute interventions, the session often extended beyond the allocated time. Various questions were raised, indicating respondents' high curiosity and interest in the provided material. The quizzes received positive feedback from respondents.

After model implementation among senior high school students, significant improvements were observed in students' knowledge, attitudes, and practices regarding adolescent hypertension prevention ($p<0.001$). Specifically, knowledge scores increased by 4.78 points, attitude scores by 10.64 points, and practice scores by 2.9 points. The pre-tests showed no significant differences in knowledge, attitude, and practices between intervention and control groups ($p>0.05$). However, in the intervention group, 1st and 2nd post-tests showed significant improvements in all variables ($p<0.05$), indicating the effectiveness of model implementation (**Table 5**).

Table 5. Impact of model implementation on knowledge, attitude, and practice of adolescent hypertension prevention

Variables	Groups		*p*-value
	Intervention, mean±SD	Control, mean±SD	
Knowledge			
Pre-test	8.42±2.90	8.44±2.74	0.969
1st post-test	11.06±2.72	8.68±2.44	0.001
2nd post-test	13.02±2.94	8.74±2.38	0.001
Attitude			
Pre-test	26.04±3.18	26.10±4.80	0.937
1st post-test	32.58±5.18	26.36±4.74	0.001
2nd post-test	36.68±5.38	26.90±4.06	0.001
Practice			
Pre-test	7.08±1.53	7.04±1.69	0.811
1st post-test	8.16±2.09	7.28±2.03	0.001
2nd post-test	9.98±2.27	7.24±1.77	0.001

Discussion

The findings of this study shed light on the concerning lack of knowledge among students regarding adolescent hypertension prevention. Despite the known risks associated with adolescent hypertension, including cardiovascular diseases and stroke, students exhibited inadequate awareness of adolescent hypertension prevention. This knowledge gap is attributed to factors such as insufficient education in schools, limited access to material, and restricted healthcare services, all of which contribute to the potential increase in chronic diseases in the future [9]. To address these issues, it is imperative to enhance education about adolescent hypertension in schools [6].

Educational initiatives should cover healthy eating habits, fast food's adverse effects, and the long-term consequences of adolescent hypertension on health [2]. Furthermore, the development of educational media, including e-modules, infographics, animated videos, and mobile applications, can facilitate engaging and accessible learning experiences for adolescents [23-25]. Physical activity plays a crucial role in hypertension prevention, yet many adolescents prioritize short-term benefits over long-term health [26]. Strategies to promote physical activity should emphasize its long-term benefits, offer tailored programs, enhance sports facilities, and provide incentives for adolescent participation [27]. Encouraging regular physical activity among adolescents is essential for reducing hypertension risk and maximizing growth and development [28].

This study differs from previous studies in intervention duration and format, emphasizing the need for nuanced approaches to adolescent hypertension prevention [24,25,29-31]. While a study spanned eight weeks and utilized traditional lecture-based methods such as PowerPoint

lectures [25], this study implemented a six-week model implementation employing e-modules, animated videos, infographics, and WhatsApp group discussions. The shorter duration and innovative delivery methods of this study model implementation may have contributed to its effectiveness in increasing knowledge, attitudes, and practices regarding adolescent hypertension prevention.

Emphasis on social interaction and support from parents, teachers, and peer educators distinguishes this study from previous study [14]. While a previous study focused primarily on educational content delivery, the model implementation of this study incorporated elements of social learning theory, fostering collaboration, communication, and knowledge sharing among adolescents [14]. Active involvement of school teachers and peer educators via WhatsApp groups facilitated engagement and knowledge retention, leading to positive behavioral outcomes.

Furthermore, incorporating mobile-based model implementation, such as through WhatsApp groups, marked a departure from the traditional approach to health education [15]. Previous studies have explored the use of digital technologies in health promotion, but few have utilized social media platforms as extensively as this study [15,24,29]. The incorporation of WhatsApp groups allowed for real-time communication, peer support, and material sharing, overcoming barriers such as distance and time constraints [24]. This study model approach demonstrated the potential of social media in facilitating health behavior change among adolescents [32].

However, several weaknesses and challenges in this study must be addressed to ensure long-term sustainability and effectiveness. Bias may persist despite validity and reliability testing, and optimal student involvement requires sufficient resources and stakeholder commitment. Cultural adaptation, particularly in diverse settings, is necessary to ensure the relevance and effectiveness of interventions. Additionally, a robust monitoring and evaluation system is essential to measure the long-term impact on adolescents' knowledge, attitudes, and practices regarding adolescent hypertension prevention.

Conclusion

Engaging and interactive materials such as e-modules, animated videos, and infographics significantly improved hypertension prevention behaviors among adolescents by enhancing their knowledge, attitudes, and practices. This study contributed valuable insights into adolescent hypertension prevention and underscored the importance of comprehensive education, social support, and innovative interventions in promoting positive health behaviors among adolescents. Collaboration among stakeholders is needed to develop sustainable initiatives for adolescent hypertension prevention on a broader scale. Future research should assess the long-term effects of multimedia interventions on adolescent health behavior, especially in larger, diverse populations. Additionally, investigating the cost-effectiveness of these interventions could help expand its use in school health programs. Scaling up such strategies could greatly improve health education effectiveness and lower hypertension rates among adolescents.

Ethics approval

This study's protocol was reviewed and approved by the Ethical Committee of Faculty of Public Health, Universitas Diponegoro, Semarang, Indonesia (Approval number: No.212/EA/KEPK-FKM/2023).

Underlying data

Derived data supporting the results of this study are available from the corresponding author on request.

How to cite

Wijayati S, Sakundarno M, Surjoputro A, Budiyono B. Enhancing adolescent hypertension prevention in Indonesia through interactive multimedia: Model development and validation. Narra J 2024; 4 (2): e881 - http://doi.org/10.52225/narra.v4i2.e881.

References

1. Song P, Zhang Y, Yu J, *et al*. Global prevalence of hypertension in children. JAMA Pediatr 2019;173(12):1154.

2. Peltzer K, Pengpid S. The prevalence and social determinants of hypertension among adults in Indonesia: A cross-sectional population-based national survey. Int J Hypertens 2018;2018:1-9.

3. Oyebode O, Pape UJ, Laverty AA, *et al*. Rural, urban and migrant differences in non-communicable disease risk-factors in middle income countries: A cross-sectional study of WHO-SAGE data. PLoS One 2015;10(4):e0122747.

4. Kurnianto A, Sunjaya DK, Rinawan FR, *et al*. Prevalence of hypertension and its associated factors among Indonesian adolescents. Int J Hypertens 2020;2020:1-7.

5. Pusparina A, Alma LR, Nurrochmah S. A cross sectional study of determinants of hypertension in Batu City, Indonesia. Proceedings of the 1st International Scientific Meeting on Public Health and Sports (ISMOPHS 2019). Paris: Atlantis Press; 2020.

6. Shaumi NRF, Achmad EK. Kajian literatur: Faktor risiko hipertensi pada remaja di Indonesia. Media Penelitian Dan Pengembangan Kesehatan 2019;29(2):115-122.

7. Ewald DR, Haldeman LA. Risk factors in adolescent hypertension. Glob Pediatr Health 2016;3:2333794X1562515.

8. Robinson CH, Chanchlani R. High blood pressure in children and adolescents: Current perspectives and strategies to improve future kidney and cardiovascular health. Kidney Int Rep 2022;7(5):954-970.

9. Börnhorst C, Russo P, Veidebaum T, *et al*. The role of lifestyle and non-modifiable risk factors in the development of metabolic disturbances from childhood to adolescence. Int J Obes 2020;44(11):2236-2245.

10. Bouhanick B, Sosner P, Brochard K, *et al*. Hypertension in children and adolescents: A position statement from a panel of multidisciplinary experts coordinated by the French Society of Hypertension. Front Pediatr 2021;7;9:680803.

11. Napit K, Shrestha KB, Magar SA, *et al*. Factors associated with utilization of adolescent-friendly services in Bhaktapur District, Nepal. J Health Popul Nutr 2020;39(1):2.

12. Kayuningtyas M, Ismayani I. Health promoting school program to prevent hypertension of adolescents in Indonesia and Western. Jurnal PROMKES 2020;8(2):228.

13. Ademe S, Aga F, Gela D. Hypertension self-care practice and associated factors among patients in public health facilities of Dessie Town, Ethiopia. BMC Health Serv Res 2019;19(1):51.

14. Nurlaily S, Yanti FD, Warsilia NNS. Pemberdayaan teman sebaya dalam memberikan edukasi dengan menggunakan media video untuk mencegah anemia pada remaja. Jurnal Masyarakat Mandiri 2023;7(1):469.

15. Kucharczuk AJ, Oliver TL, Dowdell EB. Social media's influence on adolescents' food choices: A mixed studies systematic literature review. Appetite 2022;168:105765.

16. Taylor-Zapata P, Baker-Smith CM, Burckart G, *et al*. Research gaps in primary pediatric hypertension. Pediatrics 2019;143(5):e20183517.

17. Wahid L, Indraswari R, Shaluhiyah Z, *et al*. Gambaran pelaksanaan posyandu remaja di Kelurahan Panggung Kidul Kecamatan Semarang Utara. Jurnal Kesehatan Masyarakat 2020;8(4):557-563.

18. Juandanilsyah, Hidayah F, Firngadi A, *et al*. Pengelolaan UKS di SMA. 1st ed. Jakarta: Kementerian Pendidikan dan Kebudayaan Republik Indonesia; 2021.

19. Kementerian Kesehatan Republik Indonesia. Laporan Provinsi Jawa Tengah riset kesehatan dasar 2018. Jakarta: Lembaga Penerbit Badan Litbang Kesehatan; 2019.

20. Dinas Kesehatan Provinsi Jawa Tengah. Profil kesehatan Provinsi Jawa Tengah tahun 2019. Semarang: Dinas Kesehatan Provinsi Jawa Tengah; 2019.

21. Dinas Kesehatan Kota Semarang. Profil kesehatan Kota Semarang tahun 2019. Semarang: Dinas Kesehatan Kota Semarang; 2020.

22. Kementerian Kesehatan Republik Indonesia. Hipertensi: The silent killer. Jakarta: Kementerian Kesehatan Republik Indonesia; 2019.

23. Indriawati R, Syaifudin S. Relationship between demographic factors and body mass index with the prevention of hypertension in adolescents. J Health Promot Behav 2020;5(2):72-78.

24. Ismawati D, Prasetyo I. Efektivitas pembelajaran menggunakan video Zoom Cloud Meeting pada anak usia dini era pandemi COVID-19. Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini 2020;5(1):665.

25. Wahyuni AS, Amelia R, Nababan IFF, *et al.* The difference of educational effectiveness using presentation slide method with video about prevention of hypertension on increasing knowledge and attitude in people with the hypertension risk in Amplas Health Center. Open Access Maced J Med Sci 2019;7(20):3478-3482.

26. van Sluijs EMF, Ekelund U, Crochemore-Silva I, *et al.* Physical activity behaviours in adolescence: Current evidence and opportunities for intervention. The Lancet 2021;398(10298):429-442.

27. Neil-Sztramko SE, Caldwell H, Dobbins M. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. Cochrane Database of Syst Rev 2021;9(9):CD007651.

28. Charchar FJ, Prestes PR, Mills C, *et al.* Lifestyle management of hypertension: International Society of Hypertension position paper endorsed by the World Hypertension League and European Society of Hypertension. J Hypertens 2024;42(1):23-49.

29. Marlina F, Sudiyat R. Audio visual as a medical prevention of hypertension in class X students. Jurnal Kesehatan Siliwangi 2021;2(1):214-222.

30. Aisah S, Ismail S, Margawati A. Edukasi kesehatan dengan media video animasi: Scoping review. Jurnal Perawat Indonesia 2021;5(1):641-655.

31. Azhari MA, Fayasari A. Pengaruh edukasi gizi dengan media ceramah dan video animasi terhadap pengetahuan sikap dan perilaku sarapan serta konsumsi sayur buah. Jurnal AcTion: Aceh Nutr J 2020;5(1):55.

32. Liu S, Lan Y, He G, *et al.* The associations between problematic smartphone use and blood pressure among 2,573 aged 9–17 years students in Shanghai, China. Front Public Health 2022;10:904509.

Original Article