# Statistical Analysis Plan for SMART Study

Version: 1

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Agreed by:

Date: 13th November 2023

# Overview

Smartphone usage is common among adolescence and while some studies have shown that moderate use can be beneficial for mental wellbeing, higher levels of use may be related to worse mental wellbeing outcomes. Due to the increasing prevalence of smartphones, many schools have policies dictating the use of smartphones in schools with some schools allowing smartphone use during certain times or situations during the school day, while other schools may require smartphones to be always out of sight. This study will investigate if school smartphone policies are related to student mental wellbeing outcomes.

# Study Methods

## Sample

This study is collecting quantitative and qualitative data from pupils, teachers, schools and parents. Schools from local authorities within a 100-mile radius from the University of Birmingham were included. Private schools and non-mainstream schools were excluded from the sample. Schools that had differing phone policies depending on if a pupil was in year 8 or year 10 were also excluded from our primary analysis. Since we used propensity scores to match schools, schools that were missing information related to the propensity scoring were also not included in sampling (n=10,814 schools were excluded and 36 of those were excluded due to missing data).

Due to potential differences between schools that have permissive or restrictive phone policies, propensity scoring was used to conduct stratified sampling. The variables used for propensity scores were:

- Urban/rural
- Region (East, East Midlands, Northwest, Southeast, South West, and West Midlands)
- Number of pupils
- Income Deprivation Affecting Children Index (IDACI) Decile
- Sixth form
- Religious affiliation (faith or secular)
- Admissions policy (selective or not selective)
- School type (academies/colleges/free schools, community schools, or foundation/voluntary schools)
- Percent female students
- Percent BME
- Percent of pupils whose first language is known or believed to be other than English
- Percent FSM
- Percent eligible SEN support

The outcome for the propensity scoring was a binary classification of smartphone usage policies with 1,244 schools being classified as not permissive and 97 being classified as permissive. Schools were then classified into 6 groups (based on propensity score terciles, and the two different policy groupings within each of the three propensity score strata) and randomly sampled within these groups.

## Sample size calculation

To account for the imbalance of schools in our sample that have permissive (n= 97) and restrictive policies (n =1244), we are recruiting schools using a 2:1 ratio. The primary outcome of mental wellbeing is being measured using the Warwick-Edinburgh Mental Well-Being Scale (WEMWBS; score range =14-70). To detect a mean difference in score of 3 points (considered the minimum clinically important difference between the two school groups), assuming a SD of 6.8 and an ICC of 0.1 (a conservative estimate), with 90% power and 5% significance, we require 20 schools in the restrictive and 10 schools in the permissive smartphone policy groups, with an average cluster size of 39 (1170 pupil participants in total; 780 in the restrictive, and 390 in the permissive policy groups).

In each participating class, we are aiming to recruit a minimum of 19-20 pupils (67% if estimated class size n = 30). In studies with multiple layers of clustering (here classes within schools), it is conservative to treat clusters within clusters as one larger cluster, which is the approach used here.

## Comparison Groups

We will primarily compare schools with permissive and restrictive school policies regarding smartphones.

**Table 1. Schools Smartphone Policy Categorisation and Number of Schools within each category**

| No. | Description | Number of Schools |
|---|---|---|
| 1 | Use anytime | 1 |
| 2 | Use at breaks/in zones | 9 |
| 3 | Phones off in bags (i.e. on person) | 16 |
| 4 | Phones not allowed/to be handed in/kept in lockers (i.e. not on person) | 4 |

The permissive group includes the schools that allow phones at anytime or allow phones at breaks/in zones. The restrictive group includes schools with the phones off in bags policy and the schools with phones not kept on person policy. There will also be additional analysis that further breaks down the restrictive group down into a phone off in bag policy group and a phone not allowed on person group meaning there are now three school classification groups: permissive school policy, restrictive phones off in bags policy, and restrictive phones not on person policy.

## Outcome variables

The primary outcome variable is mental wellbeing as measured by WEMWBS. This is measured two times with the first time being under supervision of researchers and the second time being only under the supervision of classroom teachers.

Secondary outcomes are:

- Anxiety, measured by the Generalized Anxiety Disorder Assessment (GAD-7) which asks questions regarding anxiety symptoms over the past 2 weeks
- Depressive symptoms, measured by the Patient Health Questionnaire (PHQ-9) which asks questions about depressive symptoms over the past two weeks
- Addictive use, measured by Problematic Social Media Use Scale (overall scores)
- Sleep quality measured by
    - Sleep duration
    - Time of falling asleep
    - Sleep efficiency (percent of time asleep versus percent of time in bed)

- Physical activity measured by
    - Moderate to vigorous physical activity
    - Overall physical activity

- Educational attainment, measured according to the tutor concerning two subjects
    - Maths (below, on, or above target)
    - English (below, on, or above target)
- Disruptive classroom behaviour, measured according to the tutor of equivalent using the Pupil Behaviour Questionnaire

We will also look at intermediate effects which include:

- Smartphone use duration for four different time periods
    - Within school
    - Over 24 hours on a school day
    - Over 24 hours on a weekend day
    - Over a full (7-day) week
- Social media use duration for four different time periods
    - Within school
    - Over 24 hours on a school day
    - Over 24 hours on a weekend day
    - Over a full (7-day) week
- Social media use motivation which measures 4 dimensions which will be looked at separately which are:
    - Coping
    - Conformity
    - Enhancement
    - Social

## Adjustment

The above outcomes and intermediate effects will be looked at in unadjusted models as well as adjusted models. School-level and pupil-level covariates will be included as adjustment variables:

**School Level**

- School Size
- IDACI
- Religious Affiliation
- Admissions Policy
- Co-Ed vs Single Sex Schools
- Month of measurement

**Pupil Level**

- Year group (year 8 age 12-13 and year 10 age 14-15)
- Sex
- Special Educational Needs Status (SEN)
- English as an Additional Language Status (EAL)
- Free School Meal Status (FSM)
- IMD

- Ethnicity
- Active/inactive travel (in only physical activity models)

Variables that may have a low number of categories per group may be aggregated further (such as going from 6 categories to 2 or 3) or variables that have a low number of schools per group (<3 schools per group) may also be aggregated.

### Missing data

We do not envisage a high proportion of missing data. We will report the amount of missing data for each variable included in the analysis. We will not impute outcome data in this study. However, we will impute data for the following:

- Where a pupil has missing IMD data, we will use the median IMD rank for pupils in their school and assigned them to the appropriate IMD quintile group.
- Where a pupil has missing D.O.B, we will use the median age for the year group in the school and assign them this age.

## Statistical Analysis

### Descriptive Statistics

We will produce tables including descriptive statistics for the following, by school smartphone policy grouping and overall:

- School characteristics
- Student demographics (year group, age, sex, ethnicity, FSM, SEN, EAL, and IMD)
- Mental and physical health outcomes (WEMWBS , GAD-7, PHQ-9, sleep time, overall physical activity, moderate to vigorous physical activity)
- Smartphone and social media use related variables (problematic social media use scale, social media use motivation, smartphone, and social media usage over four time periods)
- Student attainment and disruptive classroom behaviour

### Alpha value used, confidence intervals and effect sizes to report

An alpha of .05 will be used for the models. No alpha adjustments will be used for the secondary outcomes or intermediate effects because these are considered exploratory analyses.

### Primary analysis

Linear multilevel models will be used, with random effects allowing for repeated WEMWBS information for students, and clustering of students within classes and schools. However, we will simplify the models where appropriate when analysing the data. We will report only adjusted models for both school and pupil level variables as previously described.

### Secondary analyses

For count data outcomes (sleep duration, moderate to vigorous physical activity, overall physical activity, smartphone use duration over three time points, social media use duration over three times points) a Poisson multilevel model will be used. For proportion data or categorical data (time of falling asleep, sleep efficiency, maths and English educational attainment) a logistic or ordinal logistic multilevel model will be used. For continuous outcomes (anxiety, depression, addictive use, social media use motivation subscales, and disruptive classroom behaviour) linear multilevel regression

models will be used. Models will initially be fitted allowing for clustering of students within classes and schools, and then simplified if appropriate.

## Checking for assumptions

The assumptions for the linear multilevel regression models include:

- Linear relationship between the numerical variables and the outcomes
- Homogeneity of variance
- If the residuals are approximately normally distributed

These will be examined, and adjustments made if needed.

## Sub-group analysis and interaction effects

There are three pupil level subgroup effects that are of interest, IMD, sex, ethnicity, and year group. To evaluate these subgroups, we will separately include an interaction between school smartphone policy and the pupil characteristics (IMD, sex, ethnicity, and year group) into the models as previously described. This will allow us to investigate whether the effect of smartphone policy on our outcomes differs for pupils across these groups.

The time since the smartphone policy was implemented in each school may also affect how much school smartphone policy grouping relates to outcomes. An interaction effect for time since policy implementation will be used to see if school smartphone policies have differing relationships with outcomes based on the time since these policies were implemented.

Sensitivity analyses will be done for only the primary outcome and phone usage outcomes (for the four time periods).

## Sensitivity analysis

The primary analysis uses the WEMWBS outcome measured at two different timepoints, we will compare the two timepoints and perform a sensitivity analysis using just the initial time point for each student.

We will perform sensitivity analysis including schools that had both permissive and not permissive policies (different across year groups) as these schools will not be included in the main analysis.

All sensitivity analysis will be performed using the primary outcome and phone usage outcomes (at four timepoints).

An additional sensitivity analysis looking only at screen time will compare all phone type data with only Android data. Due to the way screen time is calculated there may have been issues with iPhones giving screen time calculations that include both iPad and Mac screen time which would inflate screen time for the iPhone group. This issue will be explored.