Estimating the association between Facebook adoption and well-being in 72 countries

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Social media's potential effects on well-being have received considerable research interest, but much of past work is hampered by an exclusive focus on demographics in the Global North and inaccurate self-reports of social media engagement. We describe associations linking 72 countries' Facebook adoption to the well-being of 946,798 individuals from 2008 to 2019. We found no associations suggesting that the global penetration of social media has caused widespread psychological harm: Facebook adoption predicted life satisfaction and positive experiences positively, and negative experiences negatively, both between countries and within countries but over time, and the associations were small. Facebook adoption was more positively associated with well-being for younger individuals, but country-specific results were mixed. In order to move beyond studying aggregates and to better understand social media's causal effects, we need more transparent collaborative research between independent scientists and the technology industry.

Keywords: well-being, social media

The ways in which people use technology for most domains in life has changed dramatically since the mass introduction of the Internet in the 1990s, and the subsequent technologies facilitated by it. Most prominently, the popularization of modern social media platforms circa 2008 precipitated widespread changes to human activities via features such as marketplaces, personalized news feeds, photo sharing, live streaming, and other features that the "metaverse" now promises to build on. The first social media with broad adoption, MySpace (launched 2003) saw 115 million users in 2008—the year in which it was replaced as the leading platform by Facebook (2004). Today (2022-Q1), Facebook reports 2.94 billion monthly active users (Meta, 2022), or about one third of the global population. Along with social media's global penetration, debate surrounding their potential effects on individual and collective well-being has intensified.

Although reports of negative psychological outcomes associated with social media are common in academic and popular writing (Kross et al., 2013; Thompson, 2021), evidence for harms is, on balance, more speculative than conclusive (Best et al., 2014; Dickson et al., 2019; Odgers & Jensen, 2020). Recent results on the associations between social media use and well-being are mixed and depend on arbitrary analytic choices (Orben et al., 2019). Other studies have reported that there have been few if any changes in associations linking technology use to mental health in this period of social media's global adoption (Vuorre et al., 2021). A general lack of validated measures, poorly specified causal models, and inadequate data have yielded a large number of low-quality studies (Parry et al., 2021; Sewall et al., 2022). Furthermore, because nearly all investigations have focused on samples from the Global North (Ghai et al., 2022), we have next to no idea of how the wider adoption of social media platforms relates to psychological well-being across the world.

To better understand the plausible range of associations, we linked data tracking Facebook's global adoption with three indicators of well-being. We examined 72 countries' per capita daily active Facebook users (DAU) in two age brackets (13-34 and 35+ years) as predictors of life satisfaction (LS), negative (NE), and positive psychological experiences (PE) at the level of years spanning 2008 to 2019. The well-being data represented 946,798 individuals' responses from the nationally representative Gallup World Poll Survey (Gallup, 2014). We joined these unique datasets to conduct a descriptive study to answer three basic yet important questions: First, to what

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The authors made the following contributions. Matti Vuorre: Design, Administration, Analysis, Visualization, Writing; Andrew K. Przybylski: Design, Administration, Funding, Resources, Supervision, Visualization, Writing.

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extent is Facebook adoption associated with well-being? Second, do these associations differ by age or sex. And finally, how might these associations have differed between countries?

Table 1

Average Facebook DAU and well-being associations

Outcome	Between country	Within country
LS	0.43% [0.33, 0.53]	0.01% [-0.02, 0.04]
NE	-0.09% [-0.19, 0.01]	-0.03% [-0.07, 0.00]
PE	0.10% [0.01, 0.19]	0.03% [0.00, 0.06]

Note. LS: Life satisfaction, NE: Negative experiences: PE: Positive experiences. Numbers indicate posterior means and 95%CIs.

Facebook adoption increased markedly from 2008 when the median per capita DAU across these 72 countries was 1% (ages 13-34) and 0%% (35+), to 77% (13-34) and 39% (35+; Figure 1A) in 2019. During this period Facebook adoption by younger individuals plateaued before saturation in many countries, but not for older individuals. At the same time, we did not observe correspondingly large and uniform changes across measures of well-being (Figure 1B) (Vuorre & Przybylski, 2022).

To answer our first question of how Facebook adoption relates to well-being, we specified a multilevel linear meta-regression model of each well-being outcome on time, sex, age, and DAU (both within- and between-country-centered, see SI). We included all interactions between sex, age, and time, and sex, age, and DAU (within-country-centered), and allowed all parameters to vary randomly across countries. We first examined whether the relative standing of countries on their average Facebook adoption predicted well-being (the model's between-country associations). We found that countries with greater average DAU had somewhat higher levels of life satisfaction and positive experiences, and lower levels of negative experiences than countries with lower DAU (Table 1). However, there are large and important differences between countries in factors that might underlie differences in both social media adoption and well-being, such as socioeconomic conditions. While descriptively informative, these associations are likely to indicate between-country confounding factors.

Variations in such confounding factors are likely to be significantly smaller within countries over time. We therefore next focused on the model's within-country associations, which measure the extent to which Facebook adoption in a given country predicted well-being in that country adjusting for general linear temporal trends in the well-being outcome. On average across age, and sex, we found that years with greater than the country's average DAU were associated with greater levels of life satisfaction and positive experiences,

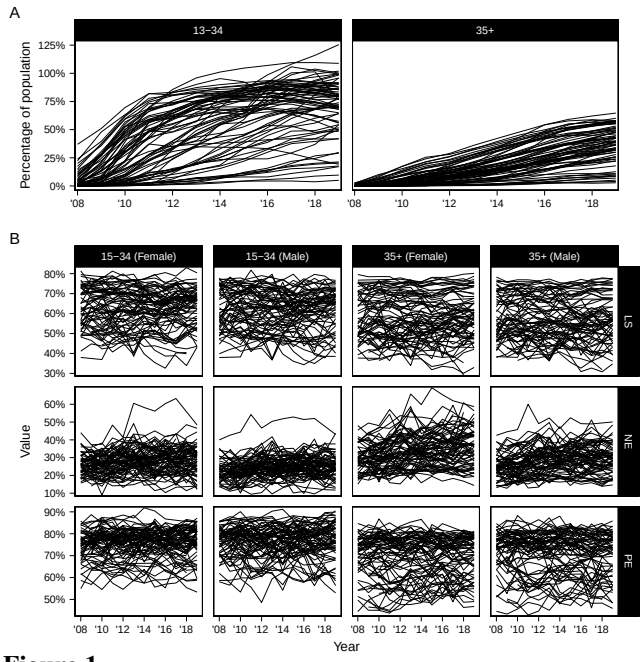

Figure 1

A. 72 countries' daily active Facebook users in two age brackets from 2008 to 2019. (Percentages may exceed 100% due to inaccurate estimation of either DAU or population size.) B. The same 72 countries' mean responses to three well-being scales in the Gallup World Poll from 2008 to 2019, separated by age category and sex. LS: Life satisfaction, NE: Negative experiences: PE: Positive experiences.

and lower levels of negative experiences (Table 1), although the first association's 95%CI contained zero. For the average country in our sample, Facebook adoption positively predicted well-being. The magnitudes of these associations were small; a one-percent increase in DAU predicted a 0.03% [0.00, 0.06] increase in positive experiences for the average country. While these associations indicate relations within countries and adjust for confounders that vary linearly with time by including time as a predictor, they are still susceptible to confounders and do not indicate causal relations. Rather, this association describes that, all else being equal, years with greater Facebook adoption tended to be those with greater levels of well-being.

We then turned to our second question and assessed whether within-country associations linking Facebook adoption to well-being differed between age and sex. Differences in the associations were greater between the younger and older demographics than they were between females and males (Figure 2, Average). DAU predicted life satisfaction more positively in the younger age bracket, but these estimates' CIs did not exclude zero. DAU predicted negative experiences negatively only in the younger age group. These differences

were less pronounced for positive experiences. These results show that Facebook adoption was, for the average nation in our sample, more positively predictive of well-being for individuals below 35, and that differences between males and females were generally smaller than those between age groups. Importantly, they did not indicate that the well-being of younger individuals is particularly linked to social media adoption.

However, while informative aggregates, these results do not describe associations between Facebook adoption and well-being for any individual country, but rather their averages. To answer our third question, we computed country-specific estimates for each sex and age group (Figure 2). For life satisfaction, 2 countries had credibly positive average associations. For negative experiences, 4 countries had credibly negative average association, and 4 countries had a credibly positive average association between DAU and positive experiences. There were no credible (at the 95% level) country-level negative associations between DAU and life-satisfaction. Although many country-level estimates were uncertain, these results aligned with the general pattern of positive associations between Facebook adoption and country-level well-being.

We found that, overall, Facebook adoption positively predicted well-being. This association held when comparing countries to other countries and to themselves over time. While these descriptive results do not speak to causal effects, they align with other recent findings suggesting that technology has not become increasingly harmful over time (Vuorre et al., 2021), and that the increased adoption of Internet technologies is not, overall, associated with widespread psychological harms (Vuorre & Przybylski, 2022). That said, these conclusions are qualified because our focus on daily active users could miss those who use Facebook less regularly. To test this possibility, we also conducted our analyses using monthly active Facebook users (MAU) as the predictor. Those results were substantively the same (see online analysis supplement).

It is widely accepted that social media and the Internet more broadly have changed how humans socialize, organize, and seek leisure, but it is not obvious or necessary that their wide adoption has influenced well-being. In this study we used the best data available to describe how global Facebook adoption relates to well-being across 72 countries over a 12-year period. We found generally positive associations between Facebook adoption and well-being which were partially qualified by demographics and not uniform across countries.

We did not find evidence that increased social media adoption is consistently negatively associated with well-being. Nevertheless, our analyses cannot and do not rule out that possibility because more fine-grained data needed to demonstrate this more conclusively either do not exist or are not available. If we are to move past description to prediction or intervention, independent scientists and online platforms will need to collaborate in new, transparent ways. As it stands

Figure 2

Forest plot of estimated associations between country-year level per-capita daily active Facebook users (DAU) and life satisfaction (LS), negative experiences (NE), and positive experiences (PE). Units indicate percentage change in outcome as function of percentage increase in within-country centered DAU. Filled points indicate estimates whose posterior 95%CI excluded zero. See the online analysis supplement for corresponding figure but with MAU as predictor.

now, only a handful of scientists working in the technology industry have the data required to advance this line of inquiry. If we are to understand and improve well-being in the digital age, this must change.

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Supporting information

Data availability

Both datasets (Facebook and Gallup) are proprietary and we therefore could not share them with this manuscript. Our analytic code, along with synthetic datasets and an online analysis supplement, is available at https://doi.org/10.5281/zenodo.7086277. Researchers can contact Facebook (ccobb@fb.com) to reproduce our analyses with the actual Facebook adoption dataset. The Gallup data are available online to subscribing institutions.

Facebook data

We studied two metrics of Facebook adoption, daily (DAU) and monthly active users (MAU), from 2008 to 2019 for 72 countries (see Figure 2). FB estimates yearly DAU & MAU with their corresponding means from June 1 to August 31, and rounds values greater than 10,000,000 to three significant digits, and values less than 10,000,000 to the nearest 10,000. We report analyses based on DAU in the main manuscript, and MAU in the online analysis supplement. Facebook calculates DAU and MAU estimates separately for individuals aged 13-34 and 35+. User age is determined based on Facebook profile information, which can be inaccurate (e.g. young users reporting an older age.) Accordingly, Facebook has trimmed 0.008% of total MAU to exclude accounts with unrealistic or non-reported ages.

In personal communication, Facebook representatives explained the selection of countries as "The countries provided were selected based upon geographic and cultural diversity and criteria related to data quality, including that geographic and age attribution error is believed to be relatively small." A given user's country is determined based on a number of factors, including the user's IP address and self-reported location.

Facebook defines users as individuals who visited Facebook or used Messenger during the appropriate period. Although accurately captured, these numbers are not perfect indicators of actual user numbers because of possible duplicate and false accounts. Facebook estimates those accounts to account for 11% and 5% of global MAUs, respectively, and that the former may be more likely in developing regions. Because internal criteria and methodology for determining duplicate and false accounts can change over time, estimates of MAU and DAU can also change.

The Facebook adoption data were made available to us on Facebook's Open Research Tool platform. Other researchers can contact Facebook (ccobb@fb.com) to access the dataset.

Well-being

Gallup World Poll (GWP) is a nationally representative annual survey of 1,000 civilian, non-institutionalised individuals aged 15 years or older from 164 countries conducted since 2005. The surveys are conducted face-to-face or on the phone in the respondents' native language and by local interviewers (for details, see (Gallup, 2014)). We studied Positive (PE) and Negative Experiences (NE), and life satisfaction. PE and NE measure respondents' experienced well-being on the day before the survey with five items each. For PE, these items are: "Did you feel well-rested yesterday?", "Were you treated with respect all day yesterday?", "Did you smile or laugh a lot yesterday?", "Did you learn or do something interesting yesterday?, and"(Did you experience the following feelings during a lot of the day yesterday?) How about enjoyment?".

The NE items are responses to "Did you experience the following feelings during a lot of the day yesterday?" for physical pain, worry, sadness, stress, and anger? For analyses we used the means of these scales. Life satisfaction in the moment was measured with one 11-step Likert item, "Please imagine a ladder, with steps numbered from 0 at the bottom to 10 at the top. The top of the ladder represents the best possible life for you and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you stand at this time?". For analyses, we scaled these variables to percentages, and aggregated the 946,798 individuals' data to means and standard errors for each country, year, sex, and age (15-34 and 35+) combination (3,136 cells).

Data analysis

Before analysing the data, we converted Facebook DAU and MAU to proportions of each country's and age group's yearly population sizes using population data from the United Nations Department of Economic and Social affairs (https://population.un.org/wpp/Download/Standard/Population/).

We examined the association between Facebook adoption and well-being through bayesian hierarchical regression models, estimated separately for DAU and MAU, and each of the three well-being outcomes. We regressed the outcome y on time (decades, centered on 2014), within-country centered x (DAU / MAU), age, sex, all the interactions except time by x, and the between-country centered DAU. We allowed all coefficients to vary randomly across the 72 countries, except the between-country predictor. Because we aggregated the outcomes, we included to standard errors of the outcome in the model to account for the varying group sizes. Formally, we specified the model as

$$
\begin{aligned}
y_i &\sim \text{Normal}(\mu_i, \sigma^{y2} v_i^2),\\
\mu_i &= \alpha_0 + \beta_{0\text{country}[i]} +\\
&\quad (\alpha_1 + \beta_{1\text{country}[i]})\text{Sex}_i +\\
&\quad (\alpha_2 + \beta_{2\text{country}[i]})\text{Age}_i +\\
&\quad (\alpha_3 + \beta_{3\text{country}[i]})\text{Time}_i +\\
&\quad (\alpha_4 + \beta_{4\text{country}[i]})\text{DAU}_i^{\text{CW}} +\\
&\quad (\alpha_5 + \beta_{5\text{country}[i]})\text{Sex}_i \times \text{Time}_i +\\
&\quad (\alpha_6 + \beta_{6\text{country}[i]})\text{Age}_i \times \text{Time}_i +\\
&\quad (\alpha_7 + \beta_{7\text{country}[i]})\text{Sex}_i \times \text{Age}_i +\\
&\quad (\alpha_8 + \beta_{8\text{country}[i]})\text{Sex}_i \times \text{Age}_i \times \text{Time}_i +\\
&\quad (\alpha_9 + \beta_{9\text{country}[i]})\text{Sex}_i \times \text{DAU}_i^{\text{CW}} +\\
&\quad (\alpha_{10} + \beta_{10\text{country}[i]})\text{Age}_i \times \text{DAU}_i^{\text{CW}} +\\
&\quad (\alpha_{11} + \beta_{11\text{country}[i]})\text{Sex}_i \times \text{Age}_i \times \text{DAU}_i^{\text{CW}} +\\
&\quad \alpha_{12}\text{DAU}_i^{\text{CB}},\\
\boldsymbol{\beta} &\sim \text{MVN}(\mathbf{0}, \Sigma).
\end{aligned}
$$

Where y_i is the outcome (e.g. life satisfaction) on row i, v_i its standard error, $\boldsymbol{\alpha}$ are the population-level coefficients, $\beta_{0,\ldots,11\text{country}[i]}$ are the country-specific coefficients for the country indicated on row i, DAU_i^{CW} the within-country centered year-aggregated daily (or monthly) active Facebook users, and DAU_i^{CB} the between-country centered DAU (or MAU).

We conducted all data analyses with the R language for statistical computing (R Core Team, 2021) and estimated the models using Stan's Hamiltonian Monte Carlo sampling via the brms R package (Bürkner, 2017). We used default noninformative priors, 4 HMC chains with 4,000 iterations and first 2,000 as warmup for 8,000 total iterations; we report all parameters with their posterior means and 95% credible intervals (posterior 2.5 and 97.5 percentiles; CI), and other posterior probabilities as indicated in text.

Online supplement to The association between Facebook adoption and well-being (Vuorre and Przybylski): Monthly active users

In the main document, we analysed associations between well-being and daily active Facebook users (DAU). Here, we repeat those analyses but use monthly active users (MAU) as the predictor

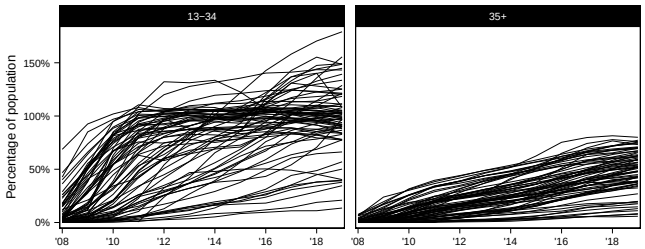

Figure S1

72 countries' monthly active Facebook users in two age brackets from 2008 to 2019. (Percentages may exceed 100% due to inaccurate estimation of either DAU or population size.)

Figure S1 shows that the trends of Facebook adoption observed for DAU for mostly similar for MAU, but the overall rates were somewhat greater. We estimated the same model as in the main analyses; the key association parameters are shown in Table S1. Overall, the results were qualitatively similar, but the associations with MAU tended to be smaller. In addition the within-country associations between life satisfaction and negative experiences and MAU were no longer credible at the 95% level.

Table S1

Average Facebook MAU and well-being associations

Outcome	Between country	Within country
LS	0.32% [0.24, 0.40]	0.01% [-0.01, 0.03]
NE	-0.06% [-0.13, 0.02]	0.00% [-0.03, 0.03]
PE	0.09% [0.02, 0.16]	0.03% [0.01, 0.06]

Note. LS: Life satisfaction, NE: Negative experiences: PE: Positive experiences. Numbers indicate posterior means and 95%CIs.

Overall, the average results across demographics mirrored those with DAU (Figure S2). However, many of the country-specific associations differed (individual countries in Figure S2). In sum, these results suggest that for associations at the level of countries, the aggregate intensity of use (monthly or daily) did not play a large role.

Figure S2

Forest plot of estimated associations between country-year level per-capita monthly active Facebook users (MAU) and life satisfaction (LS), negative experiences (NE), and positive experiences (PE). Units indicate percentage change in outcome as function of percentage increase in within-country centered MAU. Filled points indicate estimates whose posterior 95%CI excluded zero.