

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

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Abstract 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 evidence suggesting that the global penetration of social media is associated with 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. The observed associations were small. Facebook adoption predicted well-being more positively for younger individuals, but country-specific results were mixed. To move beyond studying aggregates and to better understand social media’s roles in people’s lives, and their potential causal effects, we need more transparent collaborative research between independent scientists and the technology industry.

Statement of relevance Billions of individuals across the globe use social media on a regular basis. The widespread adoption of social media—most prominently Facebook—has fundamentally shifted how humans conduct their lives. Consequently, researchers, healthcare professionals, and policy makers have repeatedly raised alarms that the spread of social media may be negatively affecting individuals’, particularly young ones’, mental health and well-being on a global scale. We examined the plausibility of this idea by associating 72 nations’ yearly Facebook adoption rates to the well-being of 946,798 individuals from 2008 to 2019. Overall, we found that increased rates of daily and monthly active Facebook users slightly predicted greater levels of well-being, when comparing countries to other countries, or countries to themselves but over time. These findings should guide debate surrounding social media towards more empirical foundations: The importance of this topic requires that independent scientists gain access to more detailed data from the technology industry in order to better determine how, when, and why modern online platforms might be affecting their users.

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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 active Facebook users 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 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? In addition, we were interested in whether the intensity of use might make a difference, and therefore conducted our analyses separately for daily active users and monthly active users.

Methods

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>. This study was not preregistered. 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 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

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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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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/>). No observations were removed for analyses.

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 DAU or MAU (in separate models), age, sex, all the interactions except time by DAU/MAU, and the between-country centered DAU/MAU. 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 and resulting uncertainties in the modelled data. Formally, we specified the model as

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

Where y_i is the outcome (e.g. life satisfaction) on row i , se_i its standard error, $\boldsymbol{\alpha}$ are the population-level coefficients, $\beta_{0,\dots,11\text{country}[i]}$ 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; Team, 2021). 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.

Results

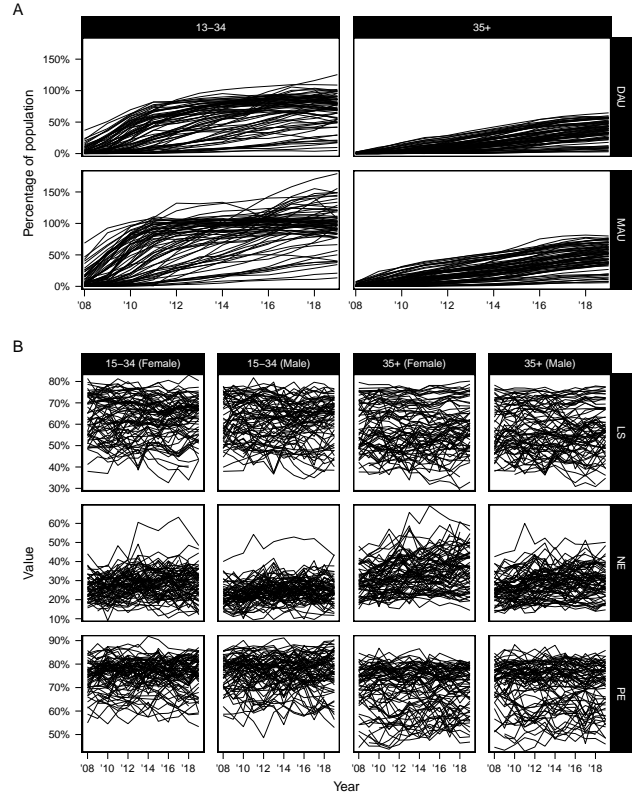


Figure 1

A. 72 countries’ daily (top) and monthly (bottom) 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.

Facebook adoption increased markedly from 2008,

when the mean per capita DAU across these 72 countries was 4% (ages 13-34) and 0% (35+), to 70% (13-34) and 37% (35+; Figure 1A) in 2019. The mean MAUs in 2019 were greater at 98% (13-34) and 49% (35+). During this period Facebook adoption by younger individuals reached near 100% 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; life satisfaction had remained relatively stable, whereas both negative and positive experiences had slightly increased (Figure 1B) (Vuorre & Przybylski, 2022).

We then focused on our first question: How Facebook adoption relates to well-being in the average country and demographic. We first examined whether and how the relative standing of countries on their average Facebook adoption predicted well-being (between-country associations, α_{12}). We found that countries with greater average daily active Facebook users (DAU) had higher levels of life satisfaction and positive experiences, and lower levels of negative experiences, than countries with lower DAU (Table 1; Between countries). 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 (Spruk & Kešeljević, 2016). While descriptively informative, these associations are therefore likely to indicate between-country confounding factors.

Table 1

Average Facebook adoption and well-being associations

X	Y	Between countries	Within-country
DAU	LS	0.42 [0.32, 0.53] (>99.9%)	0.01 [-0.02, 0.04] (81.6%)
	NE	-0.09 [-0.19, 0.00] (97.0%)	-0.04 [-0.07, 0.00] (97.2%)
	PE	0.11 [0.02, 0.20] (99.0%)	0.03 [0.00, 0.06] (98.2%)
MAU	LS	0.32 [0.24, 0.40] (>99.9%)	0.01 [-0.01, 0.03] (85.0%)
	NE	-0.06 [-0.13, 0.01] (94.7%)	0.00 [-0.03, 0.03] (51.3%)
	PE	0.08 [0.02, 0.15] (99.4%)	0.03 [0.01, 0.06] (99.9%)

Note. LS: Life satisfaction, NE: Negative experiences; PE: Positive experiences. Numbers indicate posterior means, [95%CI], and (posterior probabilities of direction).

Variations in such confounding factors are likely to be significantly smaller within countries but over time in a 12-year period. We therefore next focused on the model's within-country associations. They measure the extent to which Facebook adoption in a given country predicted well-being in that country, adjusting for temporal trends in the country's well-being outcome (α_4). For the average country and across age and sex, we found that within-country increases in DAU predicted greater levels of life satisfaction and positive experiences, and lower levels of negative experiences, although only the latter association's 95%CI excluded zero (Table 1; Within-country).

However, these results are qualified because a 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. Both the between- and within-country associations linking MAU and well-being were very similar to those linking DAU and well-being, although in general of smaller magnitude, and the within-country link between MAU and negative experiences was not credibly different from zero.

In addition to simple sign tests, we quantified evidence for the associations to be greater in magnitude to a 0.01% change as a function of 1% increase in MAU/DAU (Kruschke & Liddell, 2017). DAU predicted negative and positive experiences in excess of 0.01% with 92.8% and 93.5% probability, respectively, and MAU predicted positive experiences in excess of 0.01% with 98.5% probability. In sum, then, for the average country in our sample, Facebook adoption positively predicted well-being. Nevertheless, our certainties in the directions of these associations were not great, and the magnitudes of these associations were small: A one-percent increase in DAU predicted a 0.03 [0.00, 0.06] (98.2%) 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. DAU predicted negative experiences more negatively, and MAU positive experiences more positively, for the younger age group than for the older (0.05 [0.02, 0.08] (>99.9%), -0.02 [-0.04, 0.00] (98.4%)). Other average age differences were not credibly different from zero at the 95% level. The association between DAU and MAU and well-being was more positive for males than it was for females, across all well-being measures, but the differences were not credibly different from zero. We display the average age- and sex-specific associations in the bottom row of Figure 2. Overall, these results indicated that the association between Facebook adoption and well-being was more positive for younger individuals, particularly for negative and positive experiences, and that sex-based differences were much smaller in magnitude and not credibly different from zero.

However, while informative aggregates, these results do not describe associations between Facebook adoption and well-being for any individual country, but rather for the average country in this sample of 72 countries. 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, and 0 negative average associations

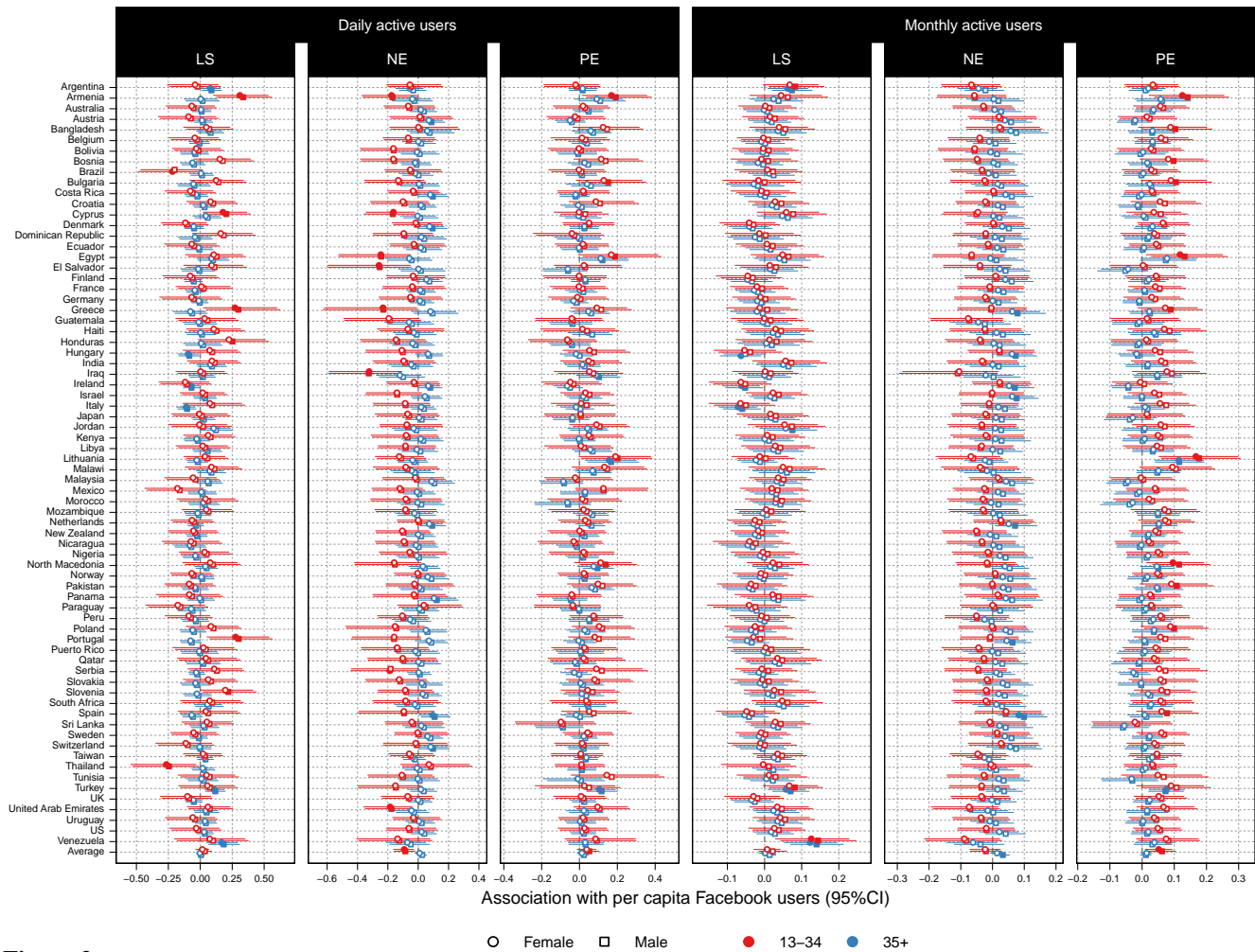


Figure 2

Within-country associations between daily (left; DAU) and monthly (right; MAU) active Facebook users 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 or MAU. Filled points indicate estimates whose 95%CI excludes zero.

with DAU. For negative experiences, 0 countries had credibly positive and 4 had negative average association. 4 countries had a credibly positive average association but 0 had a negative association, between DAU and positive experiences. The corresponding results but with MAU as the predictor were very similar. Although the country-level estimates were generally associated with large uncertainty, these results aligned with the general pattern of positive or inconclusive, rather than negative, associations between Facebook adoption and country-level well-being.

Discussion

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 psychological well-being. In this study we used the best data available to describe how two measures of Facebook adoption relate to three well-being outcomes 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.

Overall, per capita active Facebook users predicted positive experiences positively, and negative experiences negatively. These associations held when comparing countries to other countries and to themselves over time. Associations between Facebook adoption and life satisfaction were less certain within-countries, but strong when comparing countries

to each other. While these descriptive results do not speak to causal effects, they align with other recent findings suggesting that technology use has not become increasingly associated with negative psychological outcomes over time (Vuorre et al., 2021), and that the increased adoption of internet technologies in general is not, overall, associated with widespread psychological harms (Vuorre & Przybylski, 2022). We also found that Facebook adoption predicted young demographics' positive well-being more strongly than it did older demographics', and that, although males' associations were generally slightly more positive, the sex differences in this dataset were very small and not credibly different from zero. These demography-based differences, and lack therein, were notable in light of previous literature that has reported young girls to be more at-risk of screen- and technology-based effects than young males (e.g. Kelly et al., 2018; but see Kreski et al., 2021). We also compared results between analyses focusing on more intensive Facebook use to less intensive use (DAU and MAU, respectively), but the results were, by and large, in agreement.

In this study, we aimed to most accurately describe how nation-level trends in well-being are associated with Facebook adoption. As such, these data are aggregated and there are likely to be large differences within countries in the degree of social media adoption and well-being that we could not address. Our analyses also necessarily gloss over dimensions known to moderate associations between social media use and well-being, such as whether the use is active vs. passive, or whether the purpose of use is goal-directed or mere procrastination (Dienlin & Johannes, 2020; Verduyn et al., 2017). In addition, our descriptive analyses cannot and do not rule out the possibility of causal effects, either negative or positive, between social media use and well-being. More fine-grained data needed to demonstrate causal relations, or lack thereof, more conclusively either do not exist or are not available to independent scientists. We also did not make attempts at finding a representative sample of nations to study, but rather used data from countries that Facebook determined to have the most accurate data about adoption and demographics. It is therefore possible that these results would not generalize beyond the sample of 72 nations studied.

If we are to move past description, the goal of this study, to prediction or intervention, independent scientists and online platforms will need to collaborate in new, transparent ways. As it stands 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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