Health and financial costs of adverse childhood experiences in 28 European countries: a systematic review and meta-analysis

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Summary

Background Adverse childhood experiences (ACEs) are associated with increased health risks across the life course. We aimed to estimate the annual health and financial burden of ACEs for 28 European countries.

Methods In this systematic review and meta-analysis, we searched MEDLINE, CINAHL, PsycINFO, Applied Social Sciences Index and Abstracts, Criminal Justice Databases, and Education Resources Information Center for quantitative studies (published Jan 1, 1990, to Sept 8, 2020) that reported prevalence of ACEs and risks of health outcomes associated with ACEs. Pooled relative risks were calculated for associations between ACEs and harmful alcohol use, smoking, illicit drug use, high body-mass index, depression, anxiety, interpersonal violence, cancer, type 2 diabetes, cardiovascular disease, stroke, and respiratory disease. Country-level ACE prevalence was calculated using available data. Country-level population attributable fractions (PAFs) due to ACEs were generated and applied to 2019 estimates of disability-adjusted life-years. Financial costs (US$ in 2019) were estimated using an adapted human capital approach.

Findings In most countries, interpersonal violence had the largest PAFs due to ACEs (range 14·7–53·5%), followed by harmful alcohol use (15·7–45·0%), illicit drug use (15·2–44·9%), and anxiety (13·9%–44·8%). Harmful alcohol use, smoking, and cancer had the highest ACE-attributable costs in many countries. Total ACE-attributable costs ranged from $0·1 billion (Montenegro) to $129·4 billion (Germany) and were equivalent to between 1·1% (Sweden and Turkey) and 6·0% (Ukraine) of nations' gross domestic products.

Interpretation Availability of ACE data varies widely between countries and country-level estimates cannot be directly compared. However, findings suggest ACEs are associated with major health and financial costs across European countries. The cost of not investing to prevent ACEs must be recognised, particularly as countries look to recover from the COVID-19 pandemic, which interrupted services and education, and potentially increased risk factors for ACEs.

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Introduction

Awareness of the harms associated with adverse childhood experiences (ACEs) has increased substantially over the past two decades, supported by a proliferation of literature on the prevalence of ACEs and their relationships with poor life-course health.[1] The term ACEs refers to various intensive stressors that can affect children while growing up, such as suffering maltreatment, witnessing violence in the home or community, and living with family difficulties (eg, parental substance abuse).[2] Exposure to such stressors can influence children's neurological, biological, and social development and increase their susceptibility to social difficulties (eg, low educational attainment), health-harming behaviours (eg, smoking), and mental and physical illness across the life course.[3,4] Increased awareness of the links between ACEs and multi-agency priorities has driven the development of policy and practice aimed at preventing ACEs and supporting those affected by them.[5,6] However, as global attention and resources have diverted to addressing COVID–19, there are concerns that responses to the pandemic might have increased exposure to ACEs and exacerbated their effects.[7,8] Restrictions imposed to manage the pandemic have confined children and families within homes, closed essential social networks and support structures, and increased risk factors for ACEs such as unemployment and parental stress. Nations must now address the challenge of recovery, with

Research in context

Evidence before this study

A rapidly expanding evidence base links adverse childhood experiences (ACEs) to poorer health and wellbeing across the life course. Exposure to ACEs can influence neurological and physiological development and increase vulnerability to the adoption of health-harming behaviours and development of mental illness and chronic disease. Such health effects impose major costs on both individuals and society. Our previous systematic reviews have examined the associations between ACEs and health outcomes and estimated the health and financial costs of ACEs at a regional level. Thus, the financial costs of ACEs across ten health risks and causes of ill health in 2017 were estimated to be US$581 billion in Europe and $748 billion in North America; equivalent to 2·7% of Europe's and 3·5% of North America's regional gross domestic products (GDPs).

Added value of this study

With few country-level estimates of the health and financial cost of ACEs available, this study calculated such estimates for each of 28 European countries. We updated previous searches to identify additional literature on the prevalence of ACEs in country samples and their associations with health outcomes in European populations. We used meta-analyses to generate pooled relative risks for 12 health outcomes. ACE prevalence estimates were generated for each of 28 European countries using available data and were used to calculate country-level population attributable fractions for each outcome. ACE-attributable disability-adjusted life-years for 2019 were calculated and equivalent financial costs estimated. Estimated annual costs attributable to ACEs were equivalent to between 1·1% and 6·0% of countries' GDPs.

Implications of all the available evidence

ACEs are consistently related to many leading risk factors for, and causes of, ill health and estimates suggest that ACEs can impose major health and financial burdens on European nations. The extent and quality of data available to estimate costs varies widely across countries; thus, our findings here are not comparable between countries and estimates could be improved in most countries by improved data collection. Importantly, ACEs can be prevented and their costs avoided by investing in evidence-based early years, family, and resilience-building programmes. The COVID-19 pandemic has disrupted many such services and increased risk factors for ACEs. Equally, the links between ACEs, health-harming behaviours, and chronic conditions mean ACEs might increase an individual's susceptibility to COVID-19 and to the potential negative effects of restrictions imposed to control the virus. Investment choices made by governments towards pandemic recovery and future pandemic preparedness must recognise the importance of ACE prevention and support services in creating resilient societies.

investment choices being made in the face of a potential recession and competing priorities for funding. To support sound economic decision making, the costs of not investing in childhood must be recognised.

Until recently, little data were available on the economic costs of ACEs, with most studies focusing on individual adversity types such as child maltreatment.[9] However, a 2019 study estimated the annual burden of ACE exposure across ten risk factors for, and causes of, ill health to be US$581 billion in Europe and $748 billion in North America; equivalent to 2·7% of Europe's and 3·5% of North America's gross domestic product (GDP).[10] Although these figures expose the immense costs associated with ACEs, more nuanced country-level data are required to support policy development and decision making at a national level. Thus, estimates have since been published for some countries and regions. For example, in California, USA, the annual cost of ACEs across eight health risks and causes has been estimated to exceed $100 billion,[11] while in England and Wales annual costs across 13 health risks and causes of ill health have been estimated at £43 billion.[12] However, to our knowledge no cost estimates are available for other European countries.

Estimating the national costs of ACEs requires a measure of the prevalence of ACEs within a country's population. In the past few years, the number of studies measuring ACEs has burgeoned with a bibliographic review finding that almost half of studies on ACEs published between 1998 and 2018 had been published since 2017.[1] Although much research focuses on North American populations, studies are emerging from an increasing number of countries around the world, including many European countries. Thus, here we developed the approach used to produce continent-level estimates for Europe and North America,[10] to estimate the annual costs associated with ACEs in individual European countries. Using data from European studies, we calculated country-level population attributable fractions (PAFs) for one and multiple ACEs across 12 health outcomes, including four risk factors (harmful alcohol use, smoking, illicit drug use, high body-mass index [BMI]; defined as ≥25 kg/m² in all included studies) and eight causes of ill health (depression, anxiety, interpersonal violence, cancer, type 2 diabetes, cardiovascular disease, stroke, and respiratory disease). We calculated the health and financial burden of ACEs for each of 28 countries using an adapted human capital method. The study does not intend to provide comparable estimates of ACE prevalence or ACE burden between countries, but rather to develop the best estimates for each country using available data.

Methods

Search strategy and selection criteria

In this systematic review and meta-analysis, we updated searches done by Bellis and colleagues[10] in 2019 (covering Jan 1, 1990, to July 11, 2018) to identify additional quantitative studies (published July 11, 2018, to Sept 8, 2020; figure) that reported (1) prevalence of cumulative ACEs (ie, number of ACEs) and (2) risks of health outcomes associated with cumulative ACEs. We aimed to identify studies providing data that enabled an initial estimation of the cost of ACEs in various European countries. Six electronic databases (MEDLINE, CINAHL, PsycINFO, Applied Social Sciences Index and Abstracts, Criminal Justice Databases, and Education Resources Information Center) were searched with the terms "adverse childhood experience*", "adverse childhood event*", and "childhood adversit*" in title or abstract fields. Searches were done by FG, limited to journal articles published from July 11, 2018, with no language restrictions applied. Search results were extracted into Microsoft Excel. Searches were supplemented by use of author research networks. Title and abstract screening was undertaken by two reviewers (FG and EH) and full-text copies of relevant articles were obtained and screened by two reviewers (FG, EH, and KH) independently (figure).

Selected studies met the following criteria: reported on samples from WHO European region countries; focused on adults; used general population or non-high-risk samples; had a sample size of at least 1000 individuals; used a cumulative measure of at least three ACEs that included both direct (eg, maltreatment) and indirect (eg, household difficulties) types (table 1); provided prevalence data for 0 ACEs, one ACE, and multiple ACEs (in categories permitting synthesis into a category of ≥2 ACEs); and, for outcome studies, presented odds ratios (ORs), relative risks (RRs), or hazard ratios for one ACE and multiple ACEs (in categories permitting synthesis to a category of ≥2 ACEs) compared with those without ACEs. We contacted study authors for additional data to enable inclusion when possible. Studies considered for inclusion in Bellis and colleagues' 2019 study[10] were reconsidered for inclusion if they had contributed to European pooled risk ratios or met the inclusion criteria. Studies were selected for inclusion in prevalence and outcome estimates separately. For each estimate type, when more than one study reported the same data for the same sample, a single study was selected on the basis of larger sample size or data suitability. 12 health outcomes were included for which data were available from at least three studies. No specific definitions were used for outcomes (appendix p 1).

Data extraction and analysis

Included studies were independently quality assessed (by KF, FG, and EH) using criteria covering sampling approach, bias, measurement of ACEs, response rate, refuser characteristics, sample description and, for outcome studies, data analysis (appendix p 3). Data on country, study type, participants, ACE measurements, ACE prevalence, and outcome measurements were extracted independently by two reviewers and checked by a third (KH, KF, FG, and EH; appendix pp 2–3).

To calculate pooled risk estimates, RRs or ORs (adjusted for sociodemographic data when available) were extracted

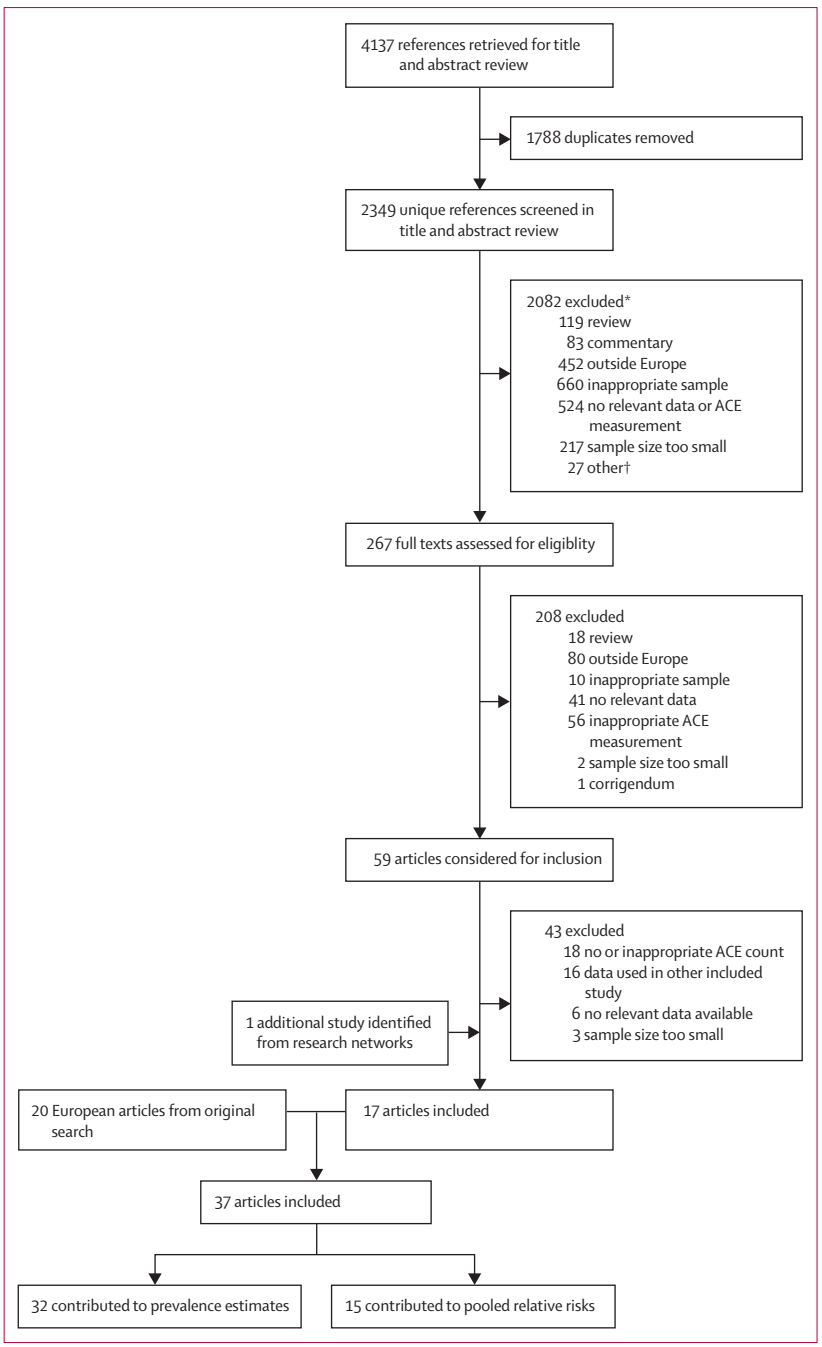

Figure: **Study selection flowchart**
The original search covered Jan 1, 1990, to July 11, 2018, and the updated search July 11, 2018, to Sept 8, 2020. ACE=adverse childhood experience. *Denotes the primary reason given but other reasons could apply. †Included case studies, corrections, and animal studies.

See Online for appendix

	Studies, n
Household substance abuse	30
Household mental illness	29
Parental separation or divorce	25
Physical abuse	24
Sexual abuse	21
Household member incarcerated or criminality	20
Exposure to domestic violence	17
Emotional, psychological, or verbal abuse	17
Parental death	15
Child welfare intervention (eg, out-of-home care)	14
Neglect	12
Family welfare or financial difficulties	10
Serious childhood illness or injury	5

Questions used to determine ACEs varied between studies. Other ACE types (measured in <3 studies) included childhood maltreatment, frequent fear of a family member, bullying, peer violence, victim of serious physical attack, frightening experience, family conflict or discord, parental affectionless control, parental dissatisfaction, parental illness or disability, separation from mother, other parental loss, sent away from home, death of a sibling, low parental concern for child's education, child labour, hunger, or residential instability. ACE=adverse childhood experience.

Table 1: **ACE types measured by included studies**

For **GBD data** see http://ghdx.healthdata.org/gbd-results-tool

For **World Bank data** see https://databank.worldbank.org/source/world-development-indicators#

from new outcome articles for each available ACE count level. ORs were transformed into RRs using RR=OR/(1−p_0+(p_0×OR)), where p_0 is the baseline risk in the absence of ACEs.[13] Two articles presented data from ACE studies using students in multiple countries;[14,15] raw data were available from these student studies and thus each study was included as a separate sample with RRs calculated using generalised linear models. Raw data were also available for five UK studies combined in one article,[12] and here study-level RRs were calculated by the authors when not included in previous estimates. For studies presenting multiple ACEs in more than one category (eg, 2–3 ACEs, ≥4 ACEs), these data were combined to an RR for at least two ACEs using a weighted mean method. Adjusted positive and negative counts by outcome and ACE category were calculated for use in meta-analyses. Existing calculations of positive and negative counts were used when studies had contributed to previous pooled RRs.[10] For each outcome, pooled RRs (95% CIs) were generated through random effects models. Heterogeneity between studies was measured using I^2 statistic (table 2).[16] Risk of publication bias was explored using Begg-Mazumdar and Egger tests and visual inspection of funnel plots when sufficient samples (>10)[16] were available.

Country-level ACE prevalence was calculated for countries with sufficient prevalence data available (≥1000 individuals; table 3). To provide a level of correction for countries' data coverage (ie, how representative available data were at a population level), country-level estimated marginal means and 95% CIs were calculated for each ACE category (0 ACE, 1 ACE, ≥2 ACEs) using a generalised linear model; weighting for sample size and incorporating data on sample country, sample age, sample representativeness, and number of ACEs measured. Estimated marginal means were adjusted towards samples that included all adult ages (*vs* younger [approximately <30 years], mid-age [approximately 30–49 years], or older samples [approximately ≥50 years]), represented their target population demographics (*vs* non-representative samples); and measured more ACEs (≥8 *vs* <8).

Country-level PAFs were calculated for each outcome and ACE level using pooled RRs and country-level ACE prevalence according to:

$$PAF_{ACE1}=\frac{P_{ACE1}\times(RR_{ACE1}-1)}{(P_{ACE0})+(P_{ACE1}\times RR_{ACE1})+(P_{ACE2+}\times RR_{ACE2+})}$$

$$PAF_{ACE2+}=\frac{P_{ACE2+}\times(RR_{ACE2+}-1)}{(P_{ACE0})+(P_{ACE1}\times RR_{ACE1})+(P_{ACE2+}\times RR_{ACE2+})}$$

where $RR_{ACE(exposure)}$ is the pooled RR associated with ACEs and $P_{ACE(exposure)}$ the proportion of the sample exposed.[17]

An adapted human capital methodology was used to calculate annual costs associated with each outcome.[9,10,18] For each country, 2019 disability-adjusted life-years (DALYs) estimates for matched Global Burden of Disease study outcomes (appendix p 1) were extracted for age categories 15–49 years, 50–69 years, and 70 years or older; and GDP and GDP per capita (2019 US$) were extracted from World Bank data. For each country, one DALY was assumed to equal GDP per capita (which ranged from $3659 in Ukraine to $81994 in Switzerland); thus, costs for each outcome were calculated using DALYs*GDP per capita. This commonly used calculation reflects a year of life lost to disability or death being unproductive; with GDP per capita being the annual economic production value of each person in a population. Country-level PAFs were applied to total DALYs and costs to estimate the economic value of DALYs lost for each outcome by ACE level. To generate a total cost of ACEs for each country, we excluded DALYs from risk factors that related to included causes to avoid double counting (eg, DALYs for smoking attributed to cancer; for each risk factor, DALYs relating to all included causes were excluded). The value of DALYs lost as a proportion of total national GDP was also calculated. In sensitivity analyses, country-level PAFs for each outcome were generated using upper and lower 95% CIs for pooled RRs, upper and lower estimates for country-level ACE prevalence, and overall ACE prevalence for all studies combined (appendix pp 8–35). Data editing and calculations were done in Microsoft Excel. Generalised linear models were done in SPSS (version 24). Meta-analyses were done using StatsDirect (version 3.1.18).

Role of the funding source

Members of the funding organisation supported identification of relevant studies through partner

	Samples, n*	Individuals, n	1 ACE		≥2 ACEs	
			Pooled relative risk (95% CI)	Heterogeneity, I^2 (95% CI)	Pooled relative risk (95% CI)	Heterogeneity, I^2 (95% CI)
Risk factors						
Harmful alcohol use	15	29 013	1·64 (1·43–1·88)	51·6% (0–71·8)	2·60 (2·07–3·27)	87·8% (81·8–91·1)
Smoking	17	32 173	1·27 (1·18–1·35)	31·7% (0–61·0)	1·74 (1·55–1·95)	83·1% (73·9–88·1)
Illicit drug use	17	32 513	1·59 (1·44–1·76)	48·6% (0–69·4)	2·63 (2·27–3·05)	84·0% (75·4–88·6)
High BMI†	5	12 586	1·02 (0·97–1·06)	0% (0–64·1)	1·07 (1·02–1·12)	36·2% (0–75·7)
Causes of ill health						
Depression	6	1 473 863	1·44 (1·34–1·56)	86·1% (69·2–91·8)	2·19 (1·92–2·51)	95·3% (92·7–96·6)
Anxiety	3	6744	1·49 (1·27–1·74)	0% (0–72·9)	2·71 (1·89–3·89)	85·1% (24·9–93·3)
Interpersonal violence	5	15 267	1·31 (0·93–1·86)	50·3% (0–79·9)	3·72 (2·79–4·97)	65·6% (0–84·7)
Cancer	6	25 035	1·13 (0·95–1·33)	30% (0–71·7)	1·51 (1·28–1·78)	18% (0–67·6)
Type 2 diabetes	5	19 178	1·15 (0·89–1·48)	65·5% (0–84·7)	1·45 (1·08–1·94)	75·7% (11·6–88·2)
Cardiovascular disease	6	20 909	1·08 (0·99–1·19)	0% (0–61)	1·46 (1·25–1·69)	36·9% (0–73·9)
Stroke	4	12 769	1·28 (0·84–1·96)	0% (0–67·9)	1·76 (1·22–2·52)	0% (0–67·9)
Respiratory disease	5	19 215	1·32 (1·09–1·59)	0% (0–64·1)	2·26 (1·88–2·72)	0% (0–64·1)

ACE=adverse childhood experience. BMI=body-mass index. *See appendix (p 2) for included studies. †Defined in included studies as BMI ≥25 kg/m².

Table 2: **Pooled relative risks for risk factors and causes of ill health**

networks, contributed to manuscript editing, and supported the decision to submit.

Results

2349 unique references were identified. Full-text copies of 267 (11·4%) articles were obtained and screened (figure). After 208 (77·9%) were excluded, 59 (22·1%) articles were considered for inclusion, along with 53 European articles drawn from the 223 articles considered in the 2019 original search. 37 articles (20 from the original search and 17 from the updated search) were selected for inclusion (figure), 15 (40·5%) of which contributed to pooled RRs and 32 (86·5%) to ACE prevalence estimates. Study characteristics are shown in the appendix (pp 2–3). 15 articles used UK samples;[12,19–32] four used multi-country samples;[14,15,33,34] two used samples from either Denmark,[35,36] Finland,[37,38] Germany,[39,40] the Netherlands,[41,42] Norway,[43,44] Sweden,[45,46] or Switzerland;[47,48] and one each from Hungary,[49] Ireland,[50] Spain,[51] and Ukraine.[52] Study sample sizes ranged from 1059 individuals to 978 647 individuals (appendix pp 2–3). Samples were predominantly drawn from general populations, but student,[14,15,39,43] primary care,[24] and public sector employee[37] samples were also included. The number and variety of ACEs collected by studies varied (table 1; appendix pp 4–5), as did definitions of several outcome measurements (appendix p 1). Outcome studies also varied in the level of adjustment for confounding, although most studies adjusted for demographic factors (appendix pp 2–3).

Table 2 presents pooled RRs for individuals with one ACE and two or more ACEs (*vs* 0 ACEs) for each outcome, with included sample numbers and sizes (forest plots are provided in the appendix pp 36–53). For all outcomes, pooled RRs increased from one ACE to two or more ACEs (table 2). RRs for one ACE ranged from 1·02 (95% CI 0·97–1·06) for high BMI to 1·64 (1·43–1·88) for harmful alcohol use, and for two or more ACEs ranged from 1·07 (1·02–1·12) for high BMI to 3·72 (2·79–4·97) for interpersonal violence (table 2). The lower boundary for the 95% CI was below 1·0 for high BMI, interpersonal violence, cancer, type 2 diabetes, cardiovascular disease, and stroke with one ACE (table 2). We found considerable heterogeneity (I^2>75%) between estimates for depression with one ACE, and for harmful alcohol use, smoking, illicit drug use, depression, anxiety, and type 2 diabetes with two or more ACEs (table 2). Begg-Mazumdar and Egger tests for bias were done for harmful alcohol use, smoking, and illicit drug use; results were only significant for harmful alcohol use with two or more ACEs (appendix pp 38, 41, 44).

The 32 studies contributing to prevalence estimates provided sufficient data to calculate estimates for 28 countries. Across all studies, adjusted prevalence of any ACE was 37·8% (one ACE, 22·6%; two or more ACEs, 15·2%; n=2 181 712 individuals; table 3). Table 3 shows adjusted ACE prevalence for each country (upper and lower estimates and unadjusted figures are given in the appendix p 6). Adjusted proportions with any ACE ranged from 20·4% (North Macedonia) to 69·4% (Finland), and for two or more ACEs ranged from 4·2% (Greece) to 38·8% (Finland; table 3). Distribution of ACE category among those with ACEs varied by country, with the proportion of individuals with any ACE reporting two or more ACEs ranging from 18·7% in Greece to 60·6% in Albania (table 3).

ACE prevalence estimates were used to calculate country-level PAFs due to ACEs for each outcome. PAFs were generated for one ACE and two or more ACEs and

	Samples, n	Sample size, n	Sample type*	Adjusted prevalence		
				0 ACEs	1 ACE	≥2 ACEs
Albania	1	1395	Students	48·4%	20·3%	31·2%
Belgium	1	2618	Older adults	69·9%	23·4%	6·8%
Czech Republic	2	3327	Students and older adults	65·6%	20·4%	14·0%
Denmark	3	985 987	General† and older adults	57·0%	28·9%	14·1%
Finland	2	32 817	General†	30·6%	30·6%	38·8%
France	1	2174	Older adults	65·9%	25·6%	8·5%
Germany	3	5748	General†, students, and older adults	51·8%	22·6%	25·6%
Greece	1	2776	Older adults	77·3%	18·4%	4·2%
Hungary	1	1174	General†	75·0%	12·0%	12·9%
Ireland	1	6408	General†	53·2%	30·8%	16·1%
Italy	1	2399	Older adults	66·8%	24·9%	8·4%
Latvia	1	1003	Students	43·1%	25·9%	31·0%
Lithuania	1	1398	Students	64·0%	19·7%	16·3%
Moldova	1	1351	Students	68·9%	16·8%	14·3%
Montenegro	1	1084	Students	72·6%	16·5%	11·0%
Netherlands	3	12 228	General† and older adults	43·8%	25·8%	30·4%
North Macedonia	1	1200	Students	79·6%	14·3%	6·1%
Norway	3	23 591	General† and students	38·0%	32·4%	29·6%
Poland	2	3446	Students and older adults	63·5%	22·7%	13·8%
Romania	1	1542	Students	62·1%	20·3%	17·6%
Russia	1	1403	Students	72·7%	15·8%	11·6%
Serbia	1	2074	Students	73·2%	16·7%	10·0%
Spain	2	4216	General† and older adults	72·8%	20·2%	7·0%
Sweden	3	1 002 796	General† and older adults	75·7%	17·2%	7·1%
Switzerland	3	7957	General† and older adults	38·3%	29·0%	32·7%
Turkey	1	1763	Students	72·1%	16·5%	11·3%
Ukraine	2	2997	General† and students	50·3%	28·9%	20·8%
UK	11	64 840	General† and older adults	53·9%	23·0%	23·0%
Overall	55	2 181 712	..	62·3%	22·6%	15·2%

Adjusted ACE prevalence levels were calculated from available study data for the purpose of generating country-level population attributable fractions and are provided for information purposes. Figures should not be assumed to be nationally representative and compared between countries because of differences in data collection methods and sample characteristics (appendix p 2). ACE=adverse childhood experience. *Students includes samples recruited from educational institutions. Older adults comprised individuals predominantly older than 50 years. †Including general population samples and those from primary care (n=1, UK) and public sector (n=1, Finland) studies.

Table 3: **Number of samples, total sample size, sample types, and resulting adjusted proportion within each ACE group by country**

summed to provide a total PAF due to ACEs. Total PAFs for each country and outcome are shown in the appendix (p 7). With the highest calculated ACE prevalence, Finland had the highest totalled PAFs due to ACEs across all outcomes, and Greece had the lowest (appendix p 7). In most countries, the largest PAFs due to ACEs were for interpersonal violence (range 14·7–53·5%); followed by harmful alcohol use (15·7–45·0%), illicit drug use (15·2–44·9%), and anxiety (13·9–44·8%; appendix p 7). High BMI had the lowest PAFs due to ACEs in all countries, ranging from 0·6% in Greece and North Macedonia to 3·1% in Finland (appendix p 7).

Country-level PAFs were applied to the equivalent number of DALYs for each outcome for 2019. ACE-attributable DALYs and associated costs for individual outcomes for each country are provided in the appendix (pp 8–35). In many countries, alcohol use, smoking, and cancer had the highest ACE-attributable costs (appendix pp 8–35). Table 4 presents total ACE-attributable DALYs (excluding those for risk factors relating to included causes) and country-level associated costs across all outcomes, and the equivalent proportion of national GDP this cost represents. The estimated number of DALYs attributable to ACEs ranged from 13 000 in Montenegro to 4·3 million in Russia (table 4). ACE-attributable costs ranged from $0·1 billion in Montenegro to $129·4 billion in Germany (table 4). The equivalent proportion of GDP accounted for by ACE-attributable costs ranged from 1·1% in Sweden and Turkey to 6·0% in Ukraine (median proportion 2·6% [IQR 1·5–3·2]; table 4).

For sensitivity analyses, in the lowest costed model, equivalent proportions of GDP accounted for by ACE-attributable costs ranged from 0·3% of GDP in Greece to 3·1% in Ukraine (appendix pp 8–35). In the upper costed model, these proportions ranged from 1·8% of GDP in Turkey to 8·9% in Ukraine (appendix pp 8–35).

Discussion

This study identifies immense health and financial costs to European nations associated with ACEs and, consequently, highlights the importance of investing in safe and nurturing childhoods. Pooled RRs indicate that adults exposed to ACEs are more likely to engage in health-risk behaviours and develop physical and mental illnesses that reduce their years of healthy and productive life. Although the proportion of DALYs and ACE-associated costs for the 12 health outcomes studied varied between countries, in all countries combined ACE-attributable costs exceeded 1% of national GDP, with the median proportion being 2·6%. This finding is similar to the previous European regional estimate of 2·7% (which used nine of 15 outcome studies included here).[10] Highest PAFs due to ACEs were seen for violence, harmful alcohol use, illicit drug use, and mental illness (anxiety and depression). As well as being costly to individuals and society, these outcomes can represent ACEs for the offspring of affected adults, with ACEs known to have intergenerational effects.[53] However, despite having lower PAFs, non-communicable diseases such as cancer and cardiovascular disease often had high costs to nations due to the high population burden of these conditions. Thus, in six countries, cancer carried the highest ACE-attributable costs of all conditions (Finland, Germany, Italy, Netherlands, Norway, and Switzerland).

Despite covering many leading health risks and causes of ill health in Europe, the actual burden of ACEs might be higher than indicated by our estimates. ACEs can stifle quality of life throughout the life course and forfeit the social benefits of healthy and resilient populations. As well as health conditions, ACEs are associated with

other major societal costs, including low educational attainment, unemployment, crime, and social deprivation.[54,55] For example, a UK study found each additional ACE was associated with a 9% earnings penalty, a 25% increased risk of welfare dependency, and a 27% increased risk of subjective poverty at age 55 years.[56] Equally, the harms associated with ACEs are not only realised in adulthood but can be seen from the earliest stages of life. Along with acute physical and emotional effects, children that have ACEs can show reduced cognitive and social development, reduced school engagement, early adoption of health-harming behaviours, and increased risk of health conditions and juvenile offending.[55,57,58] Thus, the health, social, and economic benefits of effective action to prevent and respond to ACEs would emerge far sooner than would the adult health conditions examined here.

The importance of nurturing childhoods has increasingly dominated global health policy,[59] with preventing violence against children, supporting families, and providing quality education being core features of the Sustainable Development Goals. The estimates reported here relate to a period before the COVID-19 pandemic and related restrictions. The pandemic might have increased conditions conducive to ACEs in families and reduced resilience-building opportunities if affected children are isolated in traumatic home settings and cut off from sources of support. The pandemic has also disrupted and diverted resources away from many services and programmes[60] that help prevent ACEs, such as parenting programmes, socioeconomic development programmes, and youth support services. There is a concern that the resumption of such services will be deprioritised in the drive to catch up on clinical treatment and rebuild economic opportunity. Further, individuals who have had ACEs might have been particularly affected by the pandemic because of their increased risk both of chronic conditions that increase susceptibility to severe COVID–19 symptoms (eg, respiratory disease[61]) and of broader health harms associated with the pandemic (eg, poor mental health[62]). The differential impact of the pandemic on individuals with and without ACEs is yet to be quantified. However, preventing ACEs should contribute to reducing the health-harming behaviours and health conditions that can increase a population's susceptibility to infection and thus potentially reduce health risks from future pandemics.

Our study had several limitations. Nationally representative studies measuring cumulative ACEs and associations with health were not available for most countries, and although ACE prevalence data were identified for samples in 28 countries, in many these data were restricted to students or older adults (mainly aged ≥50 years). Study methodologies varied, as did the number and types of ACEs measured. Although we adjusted ACE prevalence calculations to provide some correction for data coverage, additional nationally representative data would strengthen country estimates. However, even where such data are available, further work is required to understand how accurately studies capture ACE exposure. Many included studies used retrospective, self-reported ACE measurement, which can be affected by recall and willingness to report, whereas those using prospectively measured ACEs or administrative data might miss ACEs that were unreported or unrecorded. Consequently, estimates are likely to be more reliable in countries with multiple studies using large representative samples and various methodological approaches, such as Denmark, Sweden and the UK.

Our study relied on ACE count measurements, which do not account for the timing, severity, or length of ACE exposure and assume each ACE type carries the same weight in influencing health.[63] Further, although PAFs assume causal effects on outcomes, most included studies were cross-sectional and unable to measure causal relationships. Data from 18 countries contributed

	Population (millions)*	GDP per capita, US$, 2019	ACE-attributable DALYs (thousands)	ACE-attributable costs (US$ billion)	Equivalent % of GDP
Albania	2·9	$5352·9	79·7	$0·4	2·8%
Belgium	11·5	$46 116·7	162·6	$7·5	1·4%
Czech Republic	10·7	$23 101·8	246·5	$5·7	2·3%
Denmark	5·8	$59 822·1	136·0	$8·1	2·3%
Finland	5·5	$48 685·9	225·2	$11·0	4·1%
France	67·1	$40 493·9	939·4	$38·0	1·4%
Germany	83·1	$46 258·9	2796·6	$129·4	3·4%
Greece	10·7	$19 582·5	123·8	$2·4	1·2%
Hungary	9·8	$16 475·7	239·1	$3·9	2·4%
Ireland	4·9	$78 661·0	97·8	$7·7	2·0%
Italy	60·3	$33 189·6	916·2	$30·4	1·5%
Latvia	1·9	$17 836·4	105·0	$1·9	5·5%
Lithuania	2·8	$19 455·5	93·0	$1·8	3·3%
Moldova	2·7	$4498·5	107·6	$0·5	4·0%
Montenegro	0·6	$8832·0	13·0	$0·1	2·1%
Netherlands	17·3	$52 447·8	536·2	$28·1	3·1%
North Macedonia	2·1	$6093·1	31·6	$0·2	1·5%
Norway	5·3	$75 419·6	145·7	$11·0	2·7%
Poland	38·0	$15 595·2	941·5	$14·7	2·5%
Romania	19·4	$12 919·5	660·5	$8·5	3·4%
Russia	144·4	$11 585·0	4312·4	$50·0	2·9%
Serbia	6·9	$7402·4	191·9	$1·4	2·8%
Spain	47·1	$29 613·7	565·9	$16·8	1·2%
Sweden	10·3	$51 610·1	117·9	$6·1	1·1%
Switzerland	8·6	$81 993·7	250·5	$20·5	2·9%
Turkey	83·4	$9042·5	926·5	$8·4	1·1%
Ukraine	44·4	$3659·0	2538·9	$9·3	6·0%
UK	66·8	$42 300·3	1858·7	$78·6	2·8%

Findings should not be assumed as comparable between countries and are affected by the characteristics of contributing studies (appendix p 2). ACE=adverse childhood experience. DALY=disability-adjusted life-year. GDP=gross domestic product (current US$). *2019 figures for total population according to World Bank data.

Table 4: **Total annual ACE-attributable DALYs and costs calculated for each country**

to pooled RRs, yet for several outcomes (eg, high BMI and violence) data were only available for UK samples and for others (eg, smoking) all non-UK studies used student populations. Although we used the same set of pooled RRs in calculations for each country, differences might exist between countries in associations between ACEs and outcomes. We also found differences in definitions of outcome measurements (appendix p 1) and levels of adjustment for confounding. Thus, although most outcome studies adjusted for demographic factors, including some level of socioeconomic measurement (appendix pp 2–3), such measurements varied and key demographic factors such as ethnicity were not always included. All these factors might have affected pooled estimates and heterogeneity seen between estimates. Thus, findings should not be compared across countries and figures should be viewed as estimates that are based on the best available data. Despite these limitations, our study provides a methodology for estimating the national burden of ACEs that could be enhanced in many countries by improved data collection and replicated elsewhere by collecting ACE data. Future work would benefit from subgroup analyses to account for differences in ACE prevalence and associations between ACEs and outcomes in different population groups.

To inform prevention and its effects, improved ACE measurement within countries and increased methodological consistency are necessary. WHO has already provided leadership towards such work, which in Europe has supported implementation of ACE studies among students in 13 countries.[14,15] Elsewhere, ACE tools have been incorporated into routine population health surveys (eg, in the USA[54] and Scotland[21]). However, existing ACE tools have received criticism for issues such as measuring a restricted range of ACEs and using simplistic scoring approaches.[63] Greater availability and comparability of epidemiological evidence on ACEs and their effects could be central to obtaining political commitment to invest in prevention. Thus, greater consensus is required on the ACEs that population studies should consider, how they should be measured, and among which populations.

ACEs are associated with major health and financial costs at local, national, and international levels. The initial annual estimates calculated here quantify ACE-attributable costs for various leading health risks and causes of ill health across different European countries. These estimates could be enhanced in many countries by improved data availability. However, the burden associated with ACEs goes well beyond those directly affected by poor health, affecting education, social, and criminal justice resources. The COVID-19 pandemic could have increased risk factors for ACEs, exacerbated inequalities, and led to potential economic recessions around the world.[64,65] Effective recovery from the pandemic will require nations to make investment choices that drive sustainable economic growth, increase health equity, and build population resilience to future pandemics. This study indicates the costs that individuals and societies pay when nations do not ensure a safe and nurturing beginning for all children. Deficits in child and family support created by COVID-19 must be urgently addressed. However, after the pandemic we should go further, investing in ACE-free childhoods that propel individuals on to healthy, social, and prosperous life courses that also leave individuals more physically and mentally resilient to future pandemics.

Contributors

MAB, KH, and JP designed the study. KH, FG, EH, and KF undertook review activities including searches, study selection, data extraction, and quality assessment. MAB developed the statistical modelling. KH and KF did meta-analyses and undertook data calculations. KH wrote the manuscript with contributions from KF and MAB. KH and KF accessed and verified the data used and all authors had access to the underlying data. All authors reviewed the study findings and read and approved the final version before submission.

Declaration of interests

We declare no competing interests.

Data sharing

Study data are available from the corresponding author on reasonable request.

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