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PRACTICAL APPLICATION

How Much Should be Invested in Lung Care Across the WHO European Region? Applying a Monetary Value to Disability-Adjusted Life-Years Within the International Respiratory Coalition's Lung Facts

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Abstract

Objectives The International Respiratory Coalition's Lung Facts web resource provides the latest data on a range of lung conditions covering the World Health Organization's European Region, informed by the Global Burden of Disease studies: https://international-respiratory-coalition.org/lung-facts/. Within Lung Facts, disability-adjusted life-years (DALYs) are monetised based on gross domestic product (GDP) per capita. We describe the conceptual and empirical basis for using monetised DALYs to inform negotiations with policymakers to invest in lung care across the World Health Organization European region.

Methods We reflect on the existing debate and research evidence regarding the X value in an X*GDP per capita framework to monetise DALYs, with a focus on if 1*GDP per capita is conceptually and practically appropriate. Using an asthma case study, Global Burden of Disease study 2019 DALY estimates per country are presented. Gross domestic product per capita are converted to international dollars using purchasing power parity (Int$2019).

Results Using 1*GDP per capita, the estimated monetised asthma DALY burden, for example, in Kyrgyzstan or Germany is: across the whole population, $44,860,483 or $9,264,767,882, respectively; per 100,000 people, $731,600 or $10,208,317, respectively.

Conclusions Our indicative monetised DALY estimates can enable informed discussions with policy and decision makers, to guide financial investment in alleviating the burden of lung conditions. We suggest 1*GDP per capita as a benchmarked value forms a starting point for negotiation with policymakers for investing in lung care, by scaling the estimated lung condition DALY burden to the resource available in each country to tackle the burden.

1 Context

The newly formed International Respiratory Coalition (IRC) aims to promote lung health and improve respiratory care, with a vision for every country to have the tools to implement a national respiratory strategy based on best practice [1]. The IRC includes stakeholders such as respiratory societies, patient groups, and public health and industry specialists [2, 3].

The IRC website (https://international-respiratory-coalition.org) describes the intention and work of the IRC, as well as national projects that bring together government representatives (e.g. health ministers) with lung health-related organizations and charities to advocate for change such as investing in respiratory healthcare. In order to provide countries with the information and figures they need to advocate for change, the IRC has developed Lung Facts as an online web resource: https://international-respiratory-coalition.org/lung-facts/. Lung Facts will be updated every 2 years to provide key epidemiological and economic data for consideration within and between countries to advocate for change at the national level, with an intention to provide global evidence in the future. Lung Facts currently provides evidence for at least seven lung conditions (i.e. asthma; chronic obstructive pulmonary disease; interstitial lung disease; lower respiratory tract infection; mesothelioma; tuberculosis; tracheal, bronchus and lung cancer) across 54 countries covering the World Health Organization (WHO) European Region (53 countries) and Greenland, dependent on available evidence [4]. The concept builds from two previous European Respiratory Society *European Lung White Books* [5]; however, economic data to inform negotiation around monetary investment in lung care have been missing from the debate. For Lung Facts, epidemiological data are

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Key Points for Decision Makers

To provide countries with key epidemiological and economic data to inform lung healthcare investment and innovation, the International Respiratory Coalition has developed Lung Facts as an online web resource: https://international-respiratory-coalition.org/lung-facts/.

Within Lung Facts, the economic value of healthy years lost because of a condition is presented, by applying a cost based on a country's national wealth per citizen, referred to as the gross domestic product per capita, to a metric of healthy years lost because of specific conditions and risk factors, referred to as disability-adjusted life-years. We refer to this economic value as the societal cost of a condition's burden.

In essence, gross domestic product per capita is used to scale the value of the disability-adjusted life-year to the resources available in each country to tackle the disability-adjusted life-year burden. Thus, this societal cost is used as a reference point to suggest how much perhaps should be invested in lung care based on the equivalent potential societal cost of the lung condition burden. Within the article, examples are provided as how to use this societal cost to aid guide negotiation with policymakers to invest in lung care.

sourced from the Global Burden of Disease (GBD) studies, with condition burden quantified in disability-adjusted life-years (DALYs) [6, 7]. For the economic data, the intention is to provide a negotiation point with policymakers for budgetary investment in lung-related care technologies to alleviate the conditions' burden. For this purpose, we suggest the societal value of a DALY can be benchmarked using gross domestic product (GDP) per capita, presented based on a purchasing power parity (PPP) adjustment—the conceptual basis and practical benefits of using this benchmarked figure to inform negotiation with policymakers is described within this article.

Our aim is to inform negotiation with policymakers to allocate budgets to alleviate lung condition burden, while accounting for the wealth (i.e. GDP per capita) of countries to invest in care programmes. We reflect on health-related metrics (i.e. DALYs and quality-adjusted life-years) and methods (i.e. economic evaluations) used to guide resource-allocation decision making both for health technology appraisal (HTA) processes and across government sectors, alongside the conceptual basis and practical benefits of monetising these metrics, followed by how monetising DALYs based on GDP per capita can aid resource-allocation negotiation with country-specific policy and decision makers.

2 An Overview of Health-Related Metrics to Inform Resource Allocation: DALYs and QALYs

The DALY is a metric that allows researchers and policymakers to compare different populations and health conditions over time. Disability-adjusted life-years equal the sum of 'years of life lost' and 'years lived with disability', with Appendix S1 of the Electronic Supplementary Material (ESM) providing an overview of years of life lost and years lived with disability; a simple summary is that one DALY equals 1 lost year of healthy life [6, 7]. Disability-adjusted life-years allow us to estimate the total number of healthy years lost because of specific conditions and risk factors at the country, regional and global levels [6, 7]. Disability-adjusted life-years were developed by the WHO for their GBD Study in 1990 [8], launched as part of the 1993 *World Development Report* [9]. However, a number of GBD studies have occurred since 1990, leading to further developments to the original proposed DALY. Chen et al. [10] provide an overview of the methodological evolution of the DALY and the WHO [7] provides an update specific to the GBD estimates for 2000–19.

Disability-adjusted life-years have been used for cost-effectiveness analysis (CEA), as a widely used form of economic evaluation for the appraisal of healthcare programmes, which account for both the costs and consequences (i.e. effects or outcomes; e.g. DALYs prevented) of two (or more) alternatives [11, 12]. Another common health-related metric for CEA is the quality-adjusted life-year (QALY), described in Appendix S1 of the ESM. CEA is more commonly associated with HTA processes, which tend to focus on healthcare resources and budgets, rather than cross-sectoral (e.g. external to healthcare). An alternative form of economic evaluation is cost-benefit analysis (CBA) for the appraisal of programmes across sectors (i.e. not just healthcare), which accounts for both costs and consequences as monetary values. The advantage of monetising consequences (e.g. DALYs) is that it enables comparisons between all input and output values on a common metric, i.e. costs in a common currency [12].

3 The Economic Value of Healthy Years Lost Due to a Condition: Monetising DALYs

When operationalising DALYs (or QALYs) for economic evaluation, there is in essence a requirement to put a monetary value on those gains (i.e. $X) so they can be compared against any ‘opportunity cost’, i.e. what is foregone when investing in this output because of the resources not being available to spend elsewhere. For example, net monetary benefit (NMB) represents the value of an intervention in monetary terms when a willingness-to-pay (WTP) threshold for a natural unit of benefit (e.g. DALY) is known [13]. The use of NMB requires all outcomes (including health-related outcomes) and costs to be monetised, calculated as: *incremental benefit * WTP threshold – incremental cost* [13]. In this context, a positive/negative incremental NMB indicates that the intervention is ‘cost effective’/‘not cost effective’ compared with the alternative at the WTP threshold.

NMB uses a demand-side approach whereby opportunity cost is quantified in terms of foregone consumption, i.e. society’s consumption value of health compared with the consumption value of other non-health goods [14]. Traditionally, WTP techniques could be used to ask a population sample how much they would be willing to pay for health (e.g. a DALY prevented) relative to non-health consumption [15]. For example, greatly varied QALY WTP values have been reported in systematic reviews [16, 17], with Steigenberger et al. [18] attempting to explain what impacts this variation. Although these WTP studies are QALY specific given the lack of DALY WTP studies, it seems logical the same DALY valuation variation would remain. An alternative to this approach is calculating net health benefit based on a supply-side approach that focusses on opportunity cost in terms of health foregone when costs fall on a finite healthcare budget (i.e. a health and healthcare-only perspective) [13, 19], as described in Appendix S2 of the ESM.

4 Using Monetised Health-Related Metrics Alongside Conceptual and Empirical Considerations

Monetised health-related metrics can be operationalised in different ways to inform resource allocation. Using the UK as an example, whereas the National Institute for Health and Care Excellence (NICE) in England and Wales values the QALY as £20,000–£30,000 as a cost-effectiveness threshold for CEA, the UK’s HM Treasury values the QALY at £70,000 as a reference cost for CBA [20, 21]. Whereas NICE as an HTA agency is dominantly interested in the allocation of healthcare resources within the healthcare budget, the HM Treasury is interested in the broader allocation of resources across healthcare and non-healthcare-sector budgets, thus the reason for the alternative values and uses for economic evaluation.

Monetised health-related metrics have been particularly used as cost-effectiveness thresholds to inform HTA processes [22], for example see Table 1 derived from Zhang and Garau [23]. The idea behind these thresholds is that if a new health technology compared to an alternative can achieve an incremental benefit for less than the threshold incremental cost (e.g. NICE's threshold of £20,000–£30,000 per QALY), then it is considered ‘cost effective’ compared to the alternative. Threshold values within countries differ and depend on a country’s own particular perspective of how a threshold amount should be set; however, the conceptual basis and empirical studies for estimating these thresholds are mostly absent [24]. Zhang and Garau [23] and Schwarzer et al. [25] suggest countries do not use explicit or empirically based thresholds because of complexities with using a specific methodology for threshold setting, ethical concerns and political sensitivities. As there is no consistent empirical basis, a more suitable description for these cost-effectiveness thresholds are perhaps ‘approval norms’; i.e. a value at which it is normal to base a decision, for example a value against which cost effectiveness is judged, but has no empirical basis or conceptual underpinning. As current HTA thresholds (i.e. approval norms) are chosen by decision makers, perhaps they in part represent the decision-makers’ WTP, noting that such decision makers are working on behalf of society and so these values are perhaps proxies for societies WTP.

Outside of HTA, WTP studies have been used to guide CBA and the allocation of resources across sectors; for example, the UK’s HM Treasury *Green Book* reference value of £70,000 per QALY is based on an original QALY valuation of £60,000 in 2014, based in turn on a conversion from a Value of a Statistical Life estimate by Carthy et al. [26] using WTP methods, which the treasury inflated to 2020/21 prices [20, 26, 27]. For descriptive purposes hereafter, when decision makers operationalise monetary values for natural units (e.g. monetised DALYs or QALYs) as a decision rule, we refer to these values as thresholds or ‘approval norms’, depending on the context, whereas if they are used as a reference value that does not form a decision rule we refer to the value as a ‘benchmark’, i.e. a reference point used by decision makers which is not necessarily part of a decision rule (e.g. the HM Treasury’s £70,000 per QALY value as a reference cost).

5 Using Monetised DALYs Based on GDP per Capita to Inform Resource Allocation

Using GDP per capita to monetise DALYs stems historically from the WHO’s Choosing Interventions That Are Cost Effective (WHO-CHOICE) initiative that suggested that 1 to 3*GDP per capita could act as a country-specific cost-effectiveness threshold for CEA, based on criteria set out in the 2001 WHO’s Commission on Macroeconomics and Health (CMH) report [28–31]. More recently, the WHO-CHOICE initiative has changed its position away

Table 1 International cost-effectiveness thresholds and their associated X in a X*GDP per capita framework (Int$2019)

Country	Currency	(A) Threshold[a]	(B) PPP	(C) PPP-adjusted threshold (Int$2019) [calculation: A*1/B]	(D) PPP-adjusted GDP per capita (Int$2019)	(E) 'X' value in X*GDP per capita framework (calculation: C/D)
Australia	AUD	50,000	1.48	$33,723	$53,264	0.63
Canada	CAD	80,000	1.25	$64,162	$50,227	1.28
	CAD	50,000	1.25	$40,101	$50,227	0.80
	CAD	100,000	1.25	$80,202	$50,227	1.60
Czechia	CZK	1,615,003[c]	12.66	$127,535	$42,512	3.00
Great	GBP	20,000	0.69	$29,067	$48,771	0.60
Britain[b]	GBP	30,000	0.69	$43,601	$48,771	0.89
Ireland	EUR	45,000	0.83	$54,420	$85,560	0.64
Japan	JPY	5,000,000	104.31	$47,936	$42,162	1.14
The Netherlands	EUR	20,000[d]	0.79	$25,175	$59,904	0.42
Norway	NOK	500,000[d]	9.98	$50,124	$69,925	0.72
	NOK	275,000[d]	9.98	$27,568	$69,925	0.39
Poland	PLN	171,444[c]	1.79	$95,931	$31,977	3.00
South Korea	KRW	37,047,824[c]	864.63	$42,848	$42,848	1.00
Sweden	SEK	700,000	9.00	$77,798	$55,543	1.40
	SEK	500,000	9.00	$55,570	$55,543	1.00
USA	USD	50,000	1.00	$50,000	$63,015	0.79
	USD	150,000	1.00	$150,000	$63,015	2.38

GDP gross domestic product, *Int$2019* international dollars based on the PPP adjustment for the year 2019, *PPP* purchasing power parity

Source: Adapted based on the threshold values and notes provided by Zhang and Garau [23]; please note, no distinction has been made if a threshold is specific to the disability-adjusted life-year or quality-adjusted life-year; e.g. Great Britain (England, Wales and Scotland) use this threshold specific to the quality-adjusted life-year

PPP-adjusted threshold calculation: '(A) Threshold' multiplied by 1/'(B) PPP' (i.e. A*1/B), e.g. Australia: 50,000AUD*1/1.48 = $33,723 = PPP-adjusted threshold

'X' value in X*GDP per capita framework calculation: '(C) PPP-adjusted threshold' divided by '(D) GDP per capita' (i.e. C/D), e.g. Australia: $33,723/$53,264 = 0.63 = 'X' value in X*GDP per capita framework

Calculation notes: the PPP values in the table are rounded to 2 decimal places for presentation purposes; therefore, using the rounded values presented will lead to some rounding errors when calculating (C), (D) and (E)

[a]Please refer to Zhang and Garau [23] for full details around the origins and purpose of these thresholds

[b]Zhang and Garau [23] grouped 'England and Wales' separate to 'Scotland'; however, as Scotland uses the same thresholds as England and Wales, we have grouped these countries under Great Britain

[c]The Czech Republic, Poland and South Korea used a threshold based on 1* or 3*GDP per capita. Therefore, the threshold value is updated to represent this PPP-adjusted GDP per capita (Int$2019), and thus is not the same value as presented by Zhang and Garau [23]

[d]As reported by Zhang and Garau [23], a threshold for the Netherlands is not official and therefore considered an implicit threshold, and for Norway while an explicit threshold of 500,000NOK had been previously used, since January 2018, a stepwise system based on severity has been used and this 275,000NOK threshold is the lowest severity category implicit threshold

from using any defined threshold as a CEA decision rule, not just a GDP per capita threshold [32]. Robinson et al. [31] describes why the 1–3*GDP per capita threshold was originally chosen: a key point though is that the CMH did not explicitly address cost-effectiveness thresholds, rather it was developing estimates for use in CBA based on a demand-side approach related to WTP and Value of a Statistical Life [28, 31]. Additionally, the CMH originally focussed on gross national income per capita, which is similar to GDP and subsequently GDP per capita became the focus [28, 31]. Gross domestic product is a standard measure of value created through goods and services in a country during a certain period; as such, it measures the income earned from that production, or the total amount spent on final goods and services (less imports) [33]. Gross domestic product is a key tool to guide policymakers, investors and businesses in strategic decision making given an economy's activity, with GDP per capita a measurement of the GDP per person in a country's population, i.e. GDP per capita shows how much an economic production value can be attributed to each individual citizen, which translates to a measure of overall national wealth.

As such, the WHO report suggested that a DALY prevented should be at least equal to the per capita income,

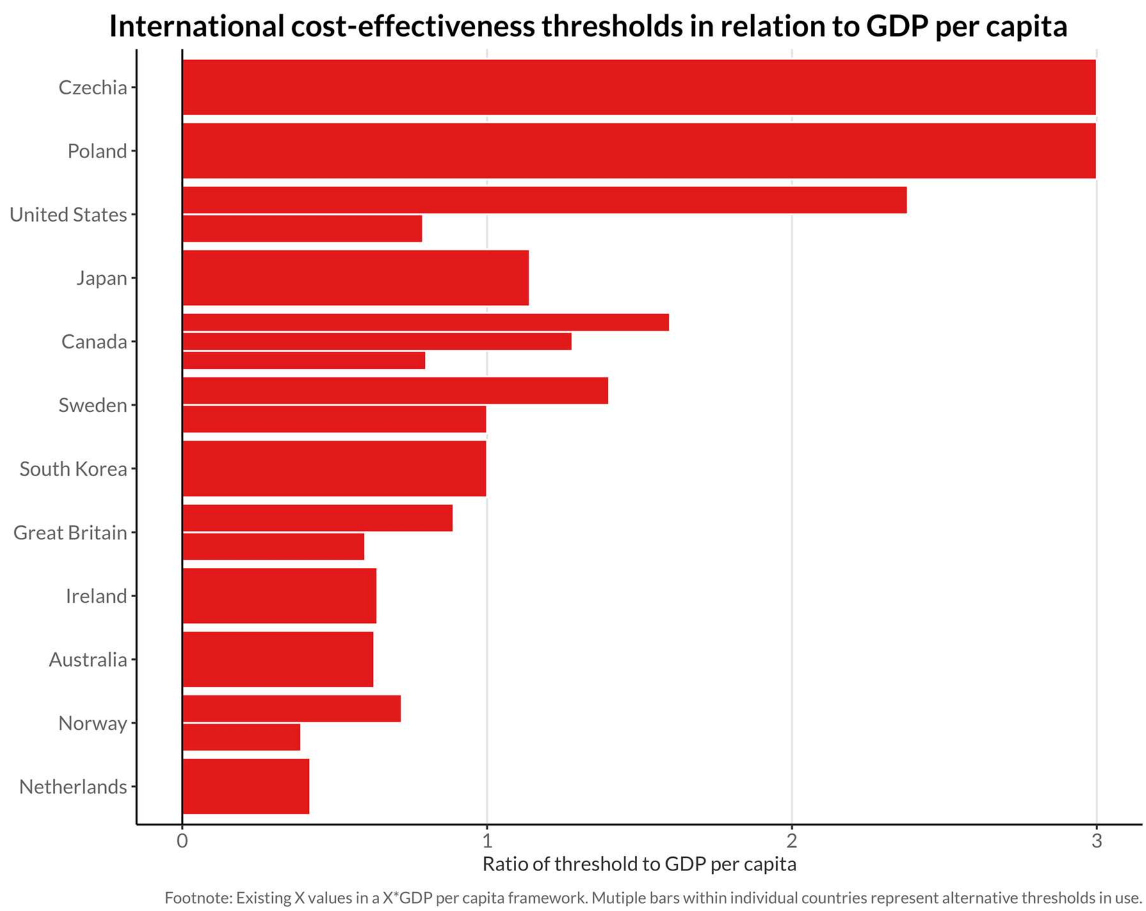

Fig. 1 International cost-effectiveness thresholds in relation to gross domestic product (GDP) per capita. Existing X values in a X*GDP per capita framework. *Multiple bars* within individual countries represent alternative thresholds in use

or extra market income, created as a result of the intervention's outcome; however, real benefits may be much higher (e.g. up to three times higher) than the per capita figure because of other non-income-based benefits (e.g. equitable outcomes such as a change in pain and suffering) [30]. Therefore, in the absence of a defined threshold, 1 up to 3*GDP per capita could be used as a country-specific threshold. The WHO-CHOICE threshold has been widely adopted internationally by researchers to help inform resource allocation within a country's decision-making process when an alternative threshold does not exist; however, the appropriateness of this threshold for CEA has been debated [31, 34–36]. A key reason why a GDP per capita-related cost-effectiveness threshold has been debated is perhaps because the GDP-related value was never intended to inform such a cost-effectiveness threshold; instead, the demand-side value and research cited by the CMH is based on WTP and Value of a Statistical Life, the same basis by which the UK's HM Treasury *Green Book* derived it £70,000 per QALY reference cost. As such, using GDP per capita may be more appropriate for monetising DALYs for CBA related to a demand-side WTP approach than a cost-effectiveness threshold for CEA, which is suggested to better align with a supply-side approach (see Appendix S2 of the ESM).

The extent to which monetising DALYs based on GDP per capita could be appropriate within CBA depends on to what extent GDP aligns and/or facilitates operationalising the demand-side concept of WTP. A systematic review comparing health-related WTP (albeit for QALYs) and GDP per capita suggests that most identified values were between 0.5 and 1.5*GDP per capita, suggesting that 1*GDP per capita might be an appropriate demand-side mid-point valuation [37]. Inference can also be taken from internationally used cost-effectiveness thresholds for HTA, given that although they are operationalised on a supply-side basis, they potentially more closely represent demand-side WTP values for policymakers as a proxy for the associated society's WTP that policymakers purport to represent. Table 1 and Fig. 1 present the X ratio for GDP per capita in PPP-adjusted Int$2019 for comparisons between countries' HTA thresholds. In general, the X value does not go as high as 3 unless

3*GDP per capita is specifically chosen (e.g. Czechia and Poland), with most X values between 0.4 and 1.6. Although these suggestions do not provide an exact figure, it suggests 1*GDP per capita does not depart widely from current WTP estimates, nor thresholds currently guiding healthcare resource allocation that are potentially representative of policymakers WTP for health-related outcomes (e.g. QALYs).

Assuming 1*GDP per capita is a reasonable benchmark monetary value for a DALY, from a demand-side perspective there is also an underlying assumption that WTP is informed and constrained by ability to pay (e.g. income/wealth of individuals or a society) [31, 38]. For example, in times of prosperity, a country's policymakers are likely to be able and willing to pay more (i.e. allocate more resources) to health and healthcare than when the country is within recession. Therefore, using GDP per capita as a benchmark in this circumstance provides an indication of changing wealth and associated potential proportional change in WTP for health and healthcare, assuming WTP for health remains consistent with levels of wealth and is not proportionally influenced by other competing policy-relevant factors (e.g. increased preference for education over health in times of prosperity). In essence, GDP per capita is used to scale the value of the DALY to the resources available in each country, which is useful when making comparisons across and between countries over time as to the WTP value of health i.e. DALYs in this case.

Monetised DALYs based on GDP per capita are by intention and design a simplistic approach to valuing the health-related DALY metric, designed to be useful as a benchmark value to inform investment in healthcare relative to other sectors of the economy; however, they should not be viewed as an accurate measure of a population's preference for spending on health (or the policymakers preference who work on behalf of the population) nor the potential value of health opportunity cost. In essence, monetised DALYs based on GDP per capita can be used to represent policymaker potential WTP as a proxy for the societal value of the DALY (i.e. as a demand-side concept) while accounting for economic wealth that dictates the general ability to buy and spend (e.g. economic activity) within an economy at a given time, which is an important consideration for budget allocation across an entire economy.

6 Methods for Monetising DALYs in Lung Facts with Example Results and Interpretations

In the absence of an empirically based monetary DALY value across or within all WHO European region countries, we focus particularly on 1*GDP per capita as a benchmark. We use asthma as a case study, with DALY estimates obtained from the GBD study 2019 [39, 40]. Data on GDP per capita are converted to a common currency (international dollars) using PPP figures (Int$2019), taken from the World Bank databases [41]. Relative to converting all currencies to a common currency using an exchange rate (e.g. USD$), PPP-adjusted figures are more stable overtime and allow a better comparison between countries. The PPP-related figures in Tables 1 and 2 are rounded figures for presentation purposes, therefore using the rounded values (e.g. to 0 decimal places in Table 2) presented will lead to some rounding errors when calculating (C), (D) and (E) in Tables 1 and 2; the figures in the tables and in Lung Facts are not based on rounded figures, thus are the more accurately calculated estimates. The countries' Human Development Index categorisations were extracted from the United Nations Development Program, which are used for descriptive purposes in order to create sub-groupings of countries for comparison based on their Human Development Index as a measure of social and economic development [42].

Table 2 provides illustrative results including 95% confidence intervals to reflect uncertainty in the estimates for the 'whole population' or 'per 100,000 people' focussing on asthma within six countries: two per Human Development Index groupings of medium (Kyrgyzstan and Tajikistan), high (Armenia and Azerbaijan) and very high (Germany and Greece) with notably different asthma DALY burdens and GDP per capita. For descriptive purposes, here we focus on the monetised DALY burden of asthma between Kyrgyzstan and Germany when we assume a DALY is valued at 1*GDP per capita: whole population, $44,860,483 versus $9,264,767,882, respectively; per 100,000 people, $731,600 versus $10,208,317, respectively. This result stems in part from the estimated mean DALYs (whole population, 7744.5 vs 160821.5; per 100,000 people, 126.3 vs 177.2) and differences in Int$2019 GDP per capita ($5793 vs $57,609); noting that the 'whole population' figures stem also from the estimated number of people in the country, whereas the 'per 100,000 people' figures remove this consideration but do not reflect the whole DALY burden within a country.

These monetised DALY estimates can be interpreted in a few ways to aid negotiation and target setting with policy and decision makers. First, a total monetary value of that condition's burden; for example, the societal cost of asthma to Kyrgyzstan based on their overall DALY burden is $44,860,483, or per 100,000 people is $731,600.

Other interpretations are dependent on if a policymaker adopts the monetised DALY valuation as a decision rule to inform investment in averting DALYs within their country; for example, if policymakers were to adopt this valuation as a decision rule, then other interpretations could include:

Table 2 Monetised DALYs for asthma based on estimated DALYs and PPP-adjusted GDP per capita in international dollars for the year 2019 (Int$2019)

Country	HDI	(A) DALYs, mean (95% CI)	(B) PPP-adjusted GDP per capita (Int$2019)	(C) Societal cost as monetised DALYs (calculation: A*B)	(D) Budget target for 1% DALY reduction (calculation: C*0.01)	(E) DALYs prevented target for $5m (calculation: $5m/B)
Total DALYs: whole population						
Kyrgyzstan	Medium	7744.5 (5436.2–11,033.5)	$5793	$44,860,483 ($31,489,516–$63,912,213)	$448,605 ($314,895–$639,122)	863
Tajikistan	Medium	12,762.3 (9476.4–17,027.9)	$3529	$45,042,303 ($33,445,294–$60,096,991)	$450,423 ($334,453–$600,970)	1417
Armenia	High	2782.4 (1850.1–3988.3)	$14,258	$39,671,357 ($26,378,658–$56,865,034)	$396,714 ($263,787–$568,650)	351
Azerbaijan	High	15,681.3 (11,998.2–21,013.5)	$15,005	$235,293,686 ($180,029,762–$315,301,913)	$2,352,937 ($1,800,298–$3,153,019)	333
Germany	Very high	160,821.5 (111,734.8–226,618.6)	$57,609	$9,264,767,882 ($6,436,931,544 to $13,055,273,870)	$92,647,679 ($64,369,315–$130,552,739)	87
Greece	Very high	23,783.4 (15,568.5–34,956.5)	$30,860	$733,966,831 ($480,451,180–$1,078,773,915)	$7,339,668 ($4,804,512–$10,787,739)	162
DALY rate: per 100,000 people						
Kyrgyzstan	Medium	126.3 (91.5–175.8)	$5793	$731,600 ($530,019–$1,018,332)	$7316 ($5300–$10,183)	863
Tajikistan	Medium	224.3 (175.2–279)	$3529	$791,628 ($618,338–$984,682)	$7916 ($6183–$9847)	1417
Armenia	High	91.1 (59.1–136)	$14,258	$1,298,900 ($842,646–$1,939,083)	$12,989 ($8426–$19,391)	351
Azerbaijan	High	172.4 (131.6–236)	$15,005	$2,586,816 ($1,974,623–$3,541,116)	$25,868 ($19,746–$35,411)	333
Germany	Very high	177.2 (117.4–258.6)	$57,609	$10,208,317 ($6,763,298–$14,897,691)	$102,083 ($67,633–$148,977)	87
Greece	Very high	212.9 (137.8–320.6)	$30,860	$6,570,193 ($4,252,572–$9,893,866)	$65,702 ($42,526–$98,939)	162

CI confidence interval, *DALY* disability-adjusted life year, *GDP* gross domestic product, *HDI* Human Development Index, *Int$2019* international dollars based on the PPP adjustment for the year 2019, *PPP* purchasing power parity

Calculation notes: the PPP-adjusted GDP per capita values in the table are rounded to 0 decimal places for presentation purposes; therefore, using the rounded values presented will lead to some rounding errors when calculating (C), (D) and (E). The DALY values were extracted to 1 decimal place from the GBD database, and therefore are the exact number used in the calculations

(1) The upper 'cost-effective' amount to eradicate the condition's burden within that country based on an estimated NMB: e.g. if the asthma DALY burden could be eradicated for ≤$44,860,483, this could be considered a cost-effective use of resources within Kyrgyzstan based on the NMB.

(2) If Germany set a target to prevent 1% of the 2019 estimated asthma DALY burden, then committing $92,647,679 (calculation: $57,609 GDP per capita * 0.01 * 160821.5 DALYs) to reach this target could be considered a cost-effective use of resources based on the NMB.

(3) If Germany were willing to commit $5,000,000 to alleviate the DALY burden of asthma, then preventing 87 DALYs (calculation: $5,000,000 budget/$57,609 GDP per capita) could be considered a cost-effective target based on the NMB.

It is important to note that when inferring 'cost effectiveness', the aforementioned examples are assuming that the new investment represents the whole of the total incremental cost of the 'new' approach compared to the 'current' approach, and any subsequent DALYs averted as the sole incremental benefit of interest that can be causally attributed to the new approach compared to the current approach.

For example, if Germany decided to invest in a national asthma care programme to eliminate 1% of their asthma DALY burden (i.e. preventing 1609 DALYs), then the incremental cost of interest is associated with the new investment in the asthma care programme (when the total investment is irrespective or inclusive of other relevant incremental costs depending on the costing perspective of interest, e.g. accounting for changes in existing healthcare resource-use patterns or broader costs such as informal carer costs or costs in other sectors) and the sole incremental benefits of interest are any DALYs averted after the care programme was introduced, which could be causally associated with the programme (e.g. compared to the introduction of other care interventions or social determinant factors), in both cases compared to current care (i.e. costs relevant to the costing perspective and DALYs before/without the asthma care programme). As such, if Germany invested $92,647,679 in the asthma care programme (irrespective or inclusive of other care costs associated with the costing perspective of interest, provided the total incremental cost equalled $92,647,679) and the care programme was shown to avert 1609 DALYs, the care program could be considered 'cost effective' as it produces a NMB gain, i.e. 1609 incremental DALYs averted * $57,609 GDP per capita − $92,647,679 incremental cost investment = $45,202 NMB gain.

This example is assuming that policymakers have adopted the monetised DALY based on 1*GDP per capita as a 'decision rule' for determining cost effectiveness within their country, otherwise the monetised DALY value should be considered a benchmark of societies cost based on the monetised burden of the disease. Furthermore, note that for this example, the GDP per capita figure (i.e. $57,609 GDP per capita) is based on its rounded value to 0 decimal places, but the societal cost figure (i.e. $92,647,679) is taken from Table 2, which is not based on a rounded figure; therefore, there may be some rounding calculation errors when using rounded figures, thus use the non-rounded figures that can be downloaded from the Lung Facts webpage: https://international-respiratory-coalition.org/lung-facts/. These examples show how monetised DALY values could be used to aid policy and decision makers in terms of the burden of a condition within a specific country, and as an indicative amount it may be worth investing to address the condition-specific DALY burden within that country under specific assumptions such as associated with demand-side approaches, WTP, CBA and NMB.

7 Discussion Including Limitations

We have provided indicative monetised DALY estimates for specific countries and lung conditions that we have compared to the concept of using 'approval norms' and 'benchmarked' values within countries to inform resource allocation decision making, focussing on an asthma case study for this article. Although 1*GDP per capita has been used to generate our estimates, these are primarily as benchmarked values to aid negotiation for lung care investment as an exact monetary value has yet to be more formally calculated based on empirical evidence and agreed upon including as part of a decision rule (i.e. operationalised as an approval norm to inform resource allocation). Although some countries do use specific thresholds, for example as approval norms to inform their HTA decision-making recommendations such as NICE in England and Wales (see Table 1), even this cost-effectiveness threshold has been criticised and subsequently debated [43–46].

Some of our suggested methods to use this benchmarked valuation, for example as part of a decision rule, is strongly dependent on the monetised DALY based on GDP per capita being adopted as an approval norm for a given country. If this country-specific valuation is not adopted as an approval norm to inform practical decision making, then interpretations (1)–(3) in Sect. 6 are not legitimate nor tenable. The other interpretation of these values as representing a benchmarked value of 'societal cost' does not hinge on our DALY valuation as an adopted decision rule, rather it aligns with the basis of more traditional CBA, which requires natural units, such as the DALY, to have a monetary value (e.g. based on WTP) in order for it to be traded off against or valued alongside other units that do have a monetary value (e.g. resources such as labour and capital), which on its own does not specifically infer a concept of 'cost effectiveness'. Additionally, Drake [47] has argued that a monetary DALY value even with limitations and flaws could be justified as its potential to "radically improve transparency and efficiency of priority setting in global health" could be worthwhile, providing other examples such as the Millennium Development Goals or the absolute poverty threshold.

Authors have suggested a range of alternatives to the GDP per capita approach for setting a threshold as a decision rule [48], with the supply-side approach gaining momentum to guide HTA processes. Sampson et al. [49] have gone as far as suggesting it is "essential" that any HTA threshold use should be informed by evidence on the opportunity costs of healthcare expenditure. Although there are conceptual arguments and empirical studies to try and reflect demand- and supply-side approaches, such estimates have not been widely operationalised by decision makers and academic debate continues as to how threshold values should be estimated. For example, Sampson et al. [49] have summarised their perceived limitations of current approaches to supply-side threshold estimations and provide recommendations to policymakers seeking to use a supply-side threshold where the evidence base is emerging or incomplete. The general advantages and disadvantages of thresholds as a decision rule have been debated by Bertram et al. [22] while reflecting on the WHO-CHOICE original GDP-based threshold. Bertram et al. [22] concluded that: "countries should be encouraged to develop a context-specific process for decision-making that is supported by legislation, has stakeholder buy-in, for example the involvement of civil society organizations and patient groups, and is transparent, consistent and fair". Additionally, Leech et al. [34] wrote a brief report that highlighted how a CEA-associated threshold can be misused to guide decision making, concluding that: "Cost-effectiveness analysis can help inform health care spending, but its value depends on incorporating assumptions that are valid for the applicable setting. Rather than rely on commonly used, generic economic thresholds, we encourage authors to use context-specific thresholds that reflect local preferences". Such stances are aspirational given their collective suggestions are not how thresholds are currently chosen and operationalised as decision rules internationally (see Sect. 4).

Thresholds particularly for HTA are currently being used for the purpose of 'approval norms' and act as a decision rule to enable decision making that aligns with a concept of cost effectiveness that is perhaps not theoretically based (e.g. demand or supply side), but allows decision makers to make tough decisions about where to invest finite resources based on such a decision rule. Within this article, we have attempted to steer away from suggesting what is a correct threshold for any given country; however, we have chosen to represent monetised DALY figures based on 1*GDP per capita as a benchmarked starting point for negotiation with policymakers. As well as explaining why GDP per capita could be used as a benchmarked value that aligns with WTP, CBA and NMB, it is important to note that if that value was adopted as an approval norm, a single approval norm value need not be the sole focus for decision making. For example, methods such as cost-effectiveness acceptability curves allow an understanding of the probability of cost effectiveness across a range of thresholds, rather than choosing a cut-off despite the benefits specific thresholds have for binary decision making, i.e. a clear point of reference by which a new health technology is described as cost effective or not compared to an alternative [50–53]. Given that in one way or another, currently used or estimated threshold values have been criticised, setting a point at which informed negotiation can begin is perhaps not ideal, but represents a common democratic process that informs resource allocation within a care system, even in the presence of established thresholds, for example Hinde et al. [54] discusses how HTA-associated thresholds do not fit local decision-maker reality when commissioning care services in the English National Health Service. However, our indicative estimates can be used alongside current debate as to the advantages and disadvantages of thresholds/approval norms/benchmarks, and academic debate related to the theoretical and practical basis for estimating such values and how they should be operationalised by decision makers. Even a flawed metric or estimate can be useful if not misleading; as suggested in a quote by the statistician George Box that is relevant for estimating thresholds, approval norms or benchmark values: "All models are wrong … some are useful" [55].

Monetised DALYs based on GDP per capita are by intention and design a simplistic approach to valuing the health-related DALY metric, but it is the approach's simplicity that makes it useful provided the subsequent estimates are not completely misleading. As such, this approach can be used in a range of other therapeutic areas and other country groups, provided it is possible to estimate the DALY burden for relevant health conditions (e.g. GBD readily provides such estimates for a range of health conditions) and the GDP per capita for a country. As the IRC and GBD are aware, epidemiological figures for health conditions can now be estimated for a whole range of countries and conditions (these estimates also have limitations and uncertainty associated with their estimation), but the economic data to inform investment to alleviate condition burden are still absent. The monetised DALY figures in Lung Facts do not replace the need for this economic data (e.g. understanding the care costs for conditions), but the benchmarked figures can be used as a reference point for how much should perhaps be invested to alleviate the condition burden as quantified by DALYs internationally, which is a useful step forward even if the underlying model for monetising DALYs has flaws.

8 Conclusions

Our benchmarked monetised DALY estimates are provided to enable more informed negotiations with policy and decision makers as to the burden of lung conditions, which could be used to guide financial investment in alleviating the burden of lung conditions within and across WHO European region countries. However, in the absence of a formally agreed upon value as a benchmark or approval norm within all countries, these values should be used as indicative to inform discussions with policy and decision makers alongside other statistics provided within Lung Facts.

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Declarations

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Availability of Data and Material Manuscript-associated data are available from the International Respiratory Coalition Lung Facts website: https://international-respiratory-coalition.org/lung-facts/. Other data sources are referenced within the article.

Code Availability Excel calculations are available upon request, although the calculations are described within the article and provided on the International Respiratory Coalition Lung Facts website: https://international-respiratory-coalition.org/lung-facts/.

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