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Change of pace: Accelerations and advances during the Millennium Development Goal era

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ABSTRACT

This paper presents a quantitative investigation of trends before and after the establishment of the U.N. Millennium Development Goals (MDGs) to determine which trajectories changed where, and to what scale of human consequence. We perform three empirical assessments: a count of countries that accelerated their rate of progress post-2000; statistical *t*-tests for differences in mean country rates of progress; and a determination of the incremental lives saved or improved (or not) due to accelerated progress above pre-MDG trends. We find that low-income countries and sub-Saharan African countries had positive acceleration on a majority of indicators and accounted for much of the world's post-2000 accelerations. Middle-income countries typically registered larger cumulative gains but less acceleration over the period. The greatest advances were in matters of life and death. At least 20.9 million and as many as 30.3 million additional lives were saved due to accelerated rates of progress, with sub-Saharan Africa accounting for approximately two-thirds of the total. Primary school completion also showed considerable overall acceleration, leading to at least 74 million more children having finished primary school. Other measures of basic needs – including undernourishment, access to water and access to sanitation – showed mixed patterns of acceleration. Headcount rates of extreme income poverty declined at an accelerated rate in most regions. Environmental indicators showed no systematic evidence of faster progress.

1. Introduction

Did the Millennium Development Goals (MDGs) make any difference? Perhaps no question is more important for assessing the results of global policy cooperation over the past 15 years. But this is a challenging question to answer empirically. Amid the world's complex crosscurrents of economics, politics, and conflict, pathways of cause and effect are difficult to discern. Moreover, the MDGs spoke to a wide range of policy priorities, so any findings are likely to vary considerably across issues and geographies.

Nonetheless, it is possible to investigate a relevant empirical cross-section of trends before and after the establishment of the MDGs: Which trajectories changed where, and to what scale of human consequence? That is the main purpose of this paper. It aims to answer the "what" questions in a manner that establishes boundaries for subsequent debate about "why" some patterns shifted while others did not.

Among skeptics, there are three common critiques of the MDGs. One is that all progress was on course to happen anyway. According to this view, the MDGs were little more than a "bureaucratic accounting exercise with scant impact on reality," according, for example, to a Financial Times editorial in September 2015. A second is that global development aggregates are driven by China and India, two very large developing countries whose progress is considered independent to multilateral system efforts. A third is that progress on development outcomes is simply a product of underlying economic growth, rather than directed policy efforts.

This paper informs an assessment of whether the first two of these critiques are correct, and thereby provides reference points to inform future investigations of the third. To our knowledge, this is the first cross-sectoral analysis of relevant trends since the conclusion of the 2015 MDG deadline. The results also provide a reference point for efforts toward the successor Sustainable Development Goals (SDGs) for 2030.

The basic logic of the analysis is presented in Fig. 1, which distills four types of stylized outcomes for each MDG issue. The horizontal axis indicates the amount of progress achieved between 1990 and 2015, the benchmarking horizon for most MDG targets. The vertical axis indicates the degree of acceleration after the

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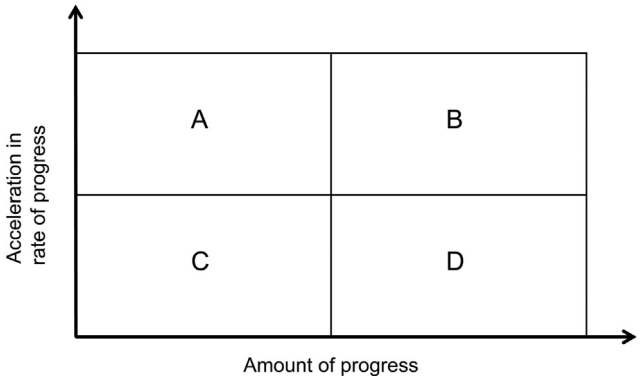

Fig. 1. Acceleration versus progress – a stylized matrix of MDG outcomes.

launch of the MDGs. On the bottom left, Quadrant C straightforwardly represents the worst-case outcome: little progress and little acceleration in the rate of progress. On the top right, Quadrant B indicates a clearly positive outcome of large absolute gains and significant acceleration in the rate of progress. However, Quadrant B is not necessarily a better outcome than Quadrant D, on the bottom right, which reflects a considerable amount of progress but little acceleration. It is possible, for example, that a pre-MDG rate of progress on an indicator was already fast and that this trend simply continued to 2015. It is also possible that maintaining a pre-existing rate of success would have amounted to a policy victory of its own, if factors were otherwise pushing toward a slowdown.

Similarly, the top left portion in Fig. 1, Quadrant A, does not necessarily reflect a worse outcome than Quadrant B. Greater absolute gains over any period are certainly preferable, but it might still represent a major breakthrough to initiate accelerated progress after a long period of stagnation or even decline. It is also not necessarily the case that the accelerated outcome A is better or worse than the overall gains under outcome D. The tension between progress and acceleration frames a central nuance for interpreting results achieved over the MDG period.

One of this paper's main contributions is to apply a consistent logic across issue areas while aiming to avoid analytical errors that would result from a simplistic one-size-fits-all methodology. The core data sample focuses on developing countries, in line with the intent of the 2000 U.N. Millennium Declaration.

The analysis differs from previous studies in three key respects. First, it segments relevant MDG targets by type. We give separate consideration for "life and death," "basic needs," "extreme income poverty," and "natural capital" categories of indicators. Second, we assess post-2000 acceleration in multiple ways: by comparing each country's before-and-after rates of progress; by conducting basic t-tests for average difference of cross-country rates of progress among different subgroups; and by translating changes in rates of progress into estimates of incremental lives saved or improved. Third, we tweak indicator-specific methods where needed, based on the substantive nature of the issue under consideration and the availability of historical data. For example, we do not test for accelerations in progress on malaria deaths among countries that did not have a significant malaria problem as of 2000. Similarly, we exclude countries from tests for acceleration on access to drinking water if they already recorded universal access as of the same year.

To stress, we do not attempt statistical tests of causality, so this study should not be interpreted as a formal assessment of MDG impact. It is in any case not clear how the MDGs should even be defined as an explanatory (right-hand side) variable, and it is difficult to discern all the pathways through which the MDGs might have played either a direct or indirect role in changing trajectories (see Appendix for further discussion). Instead, the results in this paper aim to provide a starting point for more in-depth quantitative and qualitative assessments of such questions.

2. Previous studies

Several previous studies have considered progress on individual MDG-relevant metrics. This includes multiple health-focused articles that conduct tests for country-level acceleration in progress for under-5 child mortality rates (McArthur, 2014b; Wang et al., 2014; Lange & Klasen, 2017; You et al., 2015) and maternal mortality ratios (Alkema et al., 2016; Kassebaum et al., 2014). You and colleagues also implement a counterfactual methodology previously presented in McArthur (2014b) to translate acceleration into incremental lives saved compared to 1990s trajectories.

Other earlier studies examined different combinations of MDG-linked variables over different time periods. Fukuda-Parr, Greenstein, and Stewart (2013) assessed a variety of MDG-related indicators for all developed and developing countries over the period 1990–2010, although did not present results for undernourishment, maternal mortality, malaria mortality or access to antiretroviral treatment. Their main assessment calculated whether each country experienced any measurable post-2000 acceleration relative to a linear percentage point rate of change. For child mortality, a supplemental calculation assessed acceleration based on an annual proportional rate of change. The authors reported subsets of acceleration test results for Africa and for the 48 least developed countries, finding evidence that, for 16 and 13 out of 25 indicators, respectively, a majority of countries in these groups had accelerated gains.

Kenny and Sumner (2011) examined progress across several MDG variables up to 2008 and 2009, i.e., slightly more than the first half of the MDG period. For a subset of four indicators—primary education completion rates, gender equality in education, under-5 child mortality rate (CMR), and maternal mortality ratio—the authors constructed long-term curves that fit country-level observations up to 2008 or 2009 and then assessed the extent to which the most recent values (in some cases extrapolated to 2010) deviated from the curve. They reported notable aggregate accelerations for primary education, maternal mortality, and gender equality in primary enrollment, alongside a modest acceleration for child mortality. In looking at global aggregate data, they also found evidence of an acceleration in the rate of extreme poverty reduction between 2003 and 2008 compared with 1990 to 2001–2002, but no evidence of faster progress on undernourishment or access to drinking water over the same periods.

Two analytical points are worth noting for the child mortality findings in Kenny and Sumner. One is that the paper's reported values of actual developing country CMR in 2009 do not match the underlying source data published at the time.[1] The discrepancy appears to be the result of an aggregation methodology that weights country-level values by population rather than by number of births, the latter being the appropriate match when scaling a variable with a denominator measured in births. A second point, beyond the control of the authors and with considerable consequences for interpreting long-term trends, is that official estimates of under-5 mortality rates during the early 2000s were substantially revised after the working paper's publication in 2011. For example, the 2015 U.N. data release was the last one to report aggregate "developing region" CMR values, and estimated the 2009 value to be 58 deaths per 1000 live births,

[1] Kenny and Sumner reported an "actual" CMR of 51 deaths per 1000 live births in 2009, but the official value reported at the time was 66 per 1000 live births according to U.N.-IGME (2010), the underlying source for the World Bank data which they use.

much lower than the 66 deaths per 1000 live births originally reported for that year in 2010 (UN-IGME 2010, 2015).

The significant nature of the CMR historical data revisions underscores the need for generalized caution when interpreting results related to all indicators presented in this paper. Nonetheless, if one considers the 2017 U.N.-Inter-agency Group for Child Mortality Estimation (U.N.-IGME) data set to be the best available source for CMR, one can use it to replicate Kenny and Sumner's baseline methodology while correcting for birth weights. Doing so suggests that, as of 2009, child mortality in developing countries had declined roughly an additional 11 percent below trend lines, approximately twice as big a difference as suggested by Kenny and Sumner. The increment would only grow larger over the following six years through the 2015 MDG deadline.

In another study, Friedman (2013) searched for discontinuities in rates of progress for 19 indicators between 1990 and 2010. He found evidence for positive post-2000 gains on debt relief, but not on other indicators. Because of data limitations, the study did not examine maternal mortality, undernourishment, or primary school completion, arguably three of the MDGs' most politically salient targets. Nonetheless, the paper's core question was to test for inflection points in the rate of progress. If an inflection point occurred in 2000 or earlier, Friedman considered that as evidence that the MDGs had no effect. This methodology poses an important question, but not likely the most important question.

If the question of MDG success is framed narrowly as identifying the year of an inflection point toward acceleration, then the answer would overlook the achievement of a new steady-state rate of progress, even if the steady-state is unprecedentedly high. Statistical inflection points present only partial information. A more important and relevant statistical issue would be to identify and explain any new steady-state. To be clear, the identification of a new steady-state post-2000 does not on its own imply the success of the MDGs. Conversely, if the rate of progress had been constant throughout, as Friedman indicated, that does not necessarily imply that the MDGs were not helpful, since they could have helped avoid a slowdown. There is significant risk of "Type II" (false negative) diagnostic errors if too narrow a statistical methodology is deployed. The data need to be considered from multiple angles.

Context is also crucial when interpreting the information provided by an individual indicator over time. For example, Friedman suggests that, for a sample of less developed countries, 1997 was the turning point in progress on HIV/AIDS.[2] At first glance this might be puzzling to those who know that the world's first lifesaving international antiretroviral treatment support program was not initiated until four years later, 2001, in the form of the Global Fund to Fight AIDS, Tuberculosis, and Malaria, which disbursed its first grants in 2003. This was supplemented with the 2003 launch of the major U.S. bilateral AIDS treatment program. These programs helped drive unprecedented expansions of treatment during the mid-2000s.

The discrepancy is explained by the fact that Friedman considers HIV prevalence as the variable of interest, as Fukuda-Parr et al. also did, rather than considering measures of lives saved among people with HIV/AIDS. A major limitation of this approach is that it overlooks how the dramatically expanded availability of antiretroviral treatment affected the nature and consequences of HIV infection (and hence prevalence) over the course of the 2000s. As millions of people began receiving access to treatment, HIV infection shifted from being a death sentence to a treatable disease, and international AIDS treatment targets were revised to be more ambitious at multiple junctures during the MDG period. Therefore indicators of HIV incidence and prevalence do not provide adequate information on whether someone lived or died from an infection, and offer a very narrow segment of the global HIV/AIDS story since 2000. To that end, the relevant analysis in this paper focuses on measures of lives saved and the number of people to receive lifesaving treatment.

3. Data and methods

We depart from the common practice of analyzing the MDGs in numerical order from Goal 1 onward. Instead, we categorize a cross-section of key indicators by analytical type, grouped into four categories: life and death issues, including child mortality, maternal mortality, HIV/AIDS, tuberculosis (TB), and malaria; basic needs, including water, sanitation, (under)nourishment, primary education completion, and gender parity in enrollment; extreme income poverty, measured as the head-count poverty ratio; and natural capital, for which measures of forest cover and protected land area serve as proxies. In selecting among potential indicators, we prioritize outcome-oriented variables related to outcome Goals 1 through 7, with a focus on data that had at least minimal time-series available to conduct pre- and post-2000 assessments. For health indicators, we place particular emphasis on measures directly related to mortality. We do not examine the macroeconomic enabling targets listed under Goal 8 because they were not set with quantitative benchmarks and can be considered intermediate inputs toward the core outcome variables of interest.[3]

3.1. Data

Our core sample comprises 155 of today's 193 U.N. member states that were classified as developing countries as of 2000, using World Bank criteria. Of the 155, we identify 65 that were low-income countries (LICs) and 90 that were middle-income countries (MICs) as of that year (see Appendix for details). We use these initial income classifications and World Bank regional classifications throughout the paper. To account for the large influence that China and India have on population-weighted aggregations, we frequently separate out these two countries from aggregate calculations and present them as their own unique values. We use only official data sources, many of them aggregated via the World Bank's online World Development Indicators. Some indicators have better coverage than others. For example, undernourishment data are only available for only 111 of our sample countries. Although these countries together account for 92 percent of our sample population, missing observations are likely biased toward very poor countries with weak statistical systems and high undernourishment. Primary school completion has similar country-level data gaps.

As a general caveat, we are not able to vouch for underlying data quality. Some indicators are a product of direct surveying while others represent modeled estimates. Source data are being regularly updated, with potential implications for the results presented here. Butler (2015), for example, describes considerable consequences for long-run diagnostics resulting from the UN Food and Agricultural Organization's revised global hunger trend estimates published in 2012. All findings in this paper should be interpreted with appropriate caution as indicative and only as reliable as the underlying data.

[2] Friedman defines less-developed countries as those classified by the World Bank as IDA and IDA/IBRD Blend.

[3] Note that we do not assess indicators for the MDG targets on slum dwellers, reproductive health, or youth employment, due to inherent analytical and measurement limitations among relevant data sources.

3.2. Methods

Our methodology uses average annual rates of progress from the pre-MDG period to establish "business-as-usual" (BAU) trajectories for each variable of interest, and then compares these with rates of progress following the establishment of the MDGs. In line with previous literature, we use proportional rate of change for mortality indicators, as indicated in Eq. (1). We use absolute percentage point rate of change, as indicated in Eq. (2), for basic needs, poverty, and natural capital indicators (see for example Kassebaum et al., 2014; Wang et al., 2014; You et al., 2015; Kenny & Sumner, 2011).

$$\textit{Proportional rate of change} = 1 - (m_{t+n}/m_t)^{(1/n)} \quad (1)$$

$$\textit{Absolute percentage point rate of change} = (m_{t+n} - m_t)/n \quad (2)$$

In both equations, *m* represents the indicator value, *t* represents an index year, and n indicates the number of years since *t*. Note that Eq. (1) is framed as one minus the rate of change, to align with generally declining mortality time series, whereas Eq. (2) is framed to capture progress in time series that are generally increasing. Where necessary, we adjust the calculations to account for an indicator's natural ceiling, such as 100 percent access to drinking water. For countries that hit a relevant data ceiling between 2000 and 2015, we calculate the average rate of progress up to the year when the data ceiling was hit, rather than to 2015. Further methodological details for each indicator are described in the Appendix.

Wherever possible, we conduct three key tests to assess pre- and post-MDG rates of progress. First, we simply count the number of countries that had acceleration in the annual rate of progress since the establishment of the MDGs. We consider countries to be accelerating only if their post-2000 rate of progress is positive. This test follows a similar spirit to the core results presented by Fukuda-Parr et al., while assessing a different set of indicators across the full MDG time period and noting the methodological refinements described above and below. In order to avoid overestimates of acceleration, we also extend the test to consider acceleration thresholds that carry less risk of being driven by extremely small changes in rates of progress.

Second, we conduct *t*-tests for differences in mean country rates of annual progress, independent of country size. This permits a novel assessment of both the statistical significance and quantitative extent of changes in rates of progress across MDG-relevant indicators, distilled by geographic region and initial income-group. Third, we estimate the extent to which changes in rates of progress imply differences in overall human outcomes, measured by incremental lives saved or improved (or not). For non-mortality indicators, we exclude countries from acceleration tests if they were within 1 percentage point of a relevant ceiling in 2000, such as 100 percent access to water, because it is not practical to identify discernible accelerations in progress in those situations

We divide the years 1990–2015 into pre- and post-MDG periods. Where data permit, the pre-MDG reference period is defined in two distinct ways: The first is from 1990 to 2000, and the second is the five-year period from 1996 to 2001. The latter time window is constructed to frame potentially more conservative counterfactuals, as discussed in McArthur (2014a,b). We extrapolate trends from these respective time windows to calculate counterfactual trajectories out to 2015: "Counterfactual A" uses the 1990–2000 trends and "Counterfactual B" uses the 1996–2001 trends.

Data gaps prompt the need to adjust time period definitions on some variables. For basic needs and income poverty indicators, we calculate a pre-MDG rate of progress for each country using its first available data point from 1990 to 1995 and then using either 2000 or 2001 (or 1999 if data gaps require it) as an end point. To calculate post-MDG rates of progress, we set either 2000 or 2001 as the starting point, as appropriate, and then calculate the rate of change through to the most recent observation reported from 2010 onward.

After making this time period adjustment, country-level data coverage for undernourishment and primary school completion are too limited to allow aggregate assessments of lives affected by geography and by income group. For these two variables, we instead use a combination of the World Bank's annual regional and developing country aggregates, as classified in 2016, to estimate the number of lives affected by geography.[4] We are thereby able to estimate both Counterfactual A and Counterfactual B for regional undernourishment and primary school completion. Data gaps mean that we are not able to make corresponding estimates by income group.

Country-level data gaps for extreme income poverty are particularly pronounced. Only 36 countries have adequate data to compare pre- and post-2000 rates of progress, so we conduct t-tests with corresponding caution. Here our counterfactual methodology is highly simplified because more accurate models require adjustments for trends in within-country consumption distributions (World Bank, 2016c). To enable a consistent logic across indicators, we forgo a more complicated methodology and present our poverty estimates as indicative of general magnitudes. We estimate the relevant numbers of aggregate lives affected using World Bank regional trends before and after 2002, a main reporting year for global figures, in addition to country-specific data for China and India.

4. Findings

4.1. Multidimensional assessments of progress: Child mortality

To illustrate the importance of multidimensional analysis of progress, we begin with an assessment of CMR trends disaggregated by income group and region. Fig. 2 reframes long-run CMR trends by considering the distinct annual proportional rates of progress among LICs and MICs, respectively, holding aside the populous countries of India and China. (See Appendix for results for those two countries.) Trends are weighted by each country's annual number of total births and smoothed here using three-year moving averages. The top line shows that MICs had relatively stable and high rates of average progress over four decades. In contrast, child mortality in LICs declined by an average of only 1.7 percent per year from 1975 to 2000, with the mid-1990s as the period with the slowest rate of gains—notably in the context of much higher mortality values than in MICs at the time. Then, from 2000 to 2015, the average annual rate of progress in LICs increased more than two-fold, to 3.8 percent, roughly matching the MIC rate of progress. A separate statistical test for cross-country convergence in CMR indicates that, as of approximately the turn of the millennium, a new period began in which countries at all mortality levels were experiencing similar rates of progress (see Appendix).

A subsequent layer of analysis considers changes in country-level rates of progress. We first count the number of countries that experienced acceleration after 2000. Fifty-eight of 65 LICs (89 percent) accelerated rates of progress between 1990–2000 and

[4] We use this ex-post definition of developing countries only when estimating the number of lives affected on undernourishment and primary completion rates, while noting that eighteen countries in the sample graduated to high-income status by 2016. The aggregate population for these countries was 185 million people in 2015, representing only 2.9 percent of the total sample population that year, and hence should not have large consequences for the estimation.

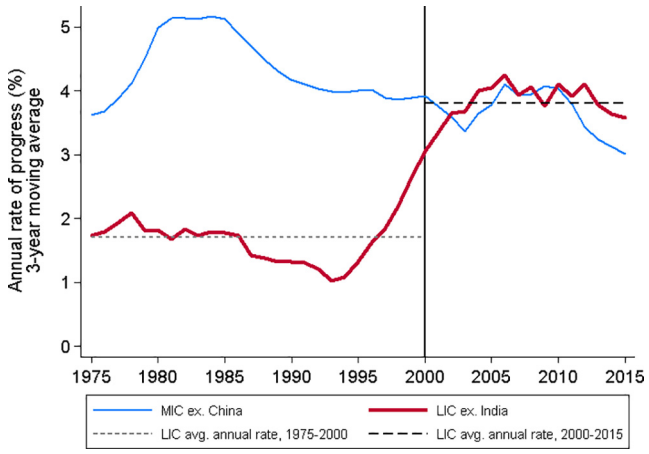

Fig. 2. Annual birth-weighted rates of progress in reducing child mortality among low-income countries (LICs) excluding India and middle-income countries (MICs) excluding China. *Source:* Authors' calculations based on UN Inter-agency Group for Child Mortality Estimation (2017).

2000–2015, and 42 (65 percent) accelerated by at least 1 percentage point per year. In contrast, only 37 of 89 MICs (42 percent) had any acceleration after 2000, although the 89 MICs had considerably faster pre-2000 average rates of progress than LICs. Corresponding results by region are available in the Appendix.

We next conduct simple *t*-tests comparing rates of progress in reducing CMR pre-2000 versus post-2000 (see Table 2). Both LICs and Africa experienced an average acceleration of more than 2 percentage points per year compared to the 1990s, statistically significant at the 1 percent level. LICs accelerated from 2.0 percent per year during the 1990s to 4.4 percent per year after 2000. Africa accelerated from 1.1 percent to 4.0 percent per year. The findings are generally similar although less pronounced when conducting the more restrictive Counterfactual B comparison between 1996–2001 and 2001–2015 (see Appendix for results). Europe and Central Asia and South Asia are the only regions with materially different results under the two different counterfactual scenarios. Using the Counterfactual A time period comparison, progress in Europe and Central Asia accelerated by 1.7 percentage points per year, significant at 5 percent levels, although there is no statistical difference in rates of progress under Counterfactual B. Similarly, rates of progress in South Asia accelerated by 0.9 percentage points per year under Counterfactual A, significant at 5 percent levels, but there was no statistical difference under Counterfactual B. No other regions experienced significant accelerations, although Latin America and the Caribbean did undergo a statistically significant slowdown under both counterfactuals, including from 3.7 percent per year in 1990–2000 to 2.9 percent in 2000–2015.

Taken together, the above results suggest that the nature of global CMR progress post-2000 has been structurally different than during previous periods, especially for the poorest countries and those in Africa. For our third test, we consider the absolute human implications of changing CMR trends. Under Counterfactual A, we find that an incremental 18.7 million children survived to their fifth birthday during the period 2001–2015, compared with business as usual (BAU) trajectories as of 1990–2000. Under Counterfactual B, the corresponding figure is 9.7 million additional lives over 2002–2015. Fig. 3 shows how the path of child deaths would have differed under Counterfactual A and Counterfactual B, compared with the actual reported trajectory. For completeness it also shows the trajectory if the MDG had been exactly achieved by all developing countries: A further 8.8 million lives would have been saved.

4.2. Country-count acceleration test

Now turning to the full cross-section of relevant indicators, Table 1 shows the number of countries that experienced acceleration for all relevant indicators after 2000. Results grouped by geography are available in the Appendix. We distinguish between "any" and "real" acceleration – the former indicating a change greater than zero and the latter indicating at least a 1 percentage point change in annual proportional progress for child mortality, maternal mortality, and malaria deaths, or a 0.33 percentage point change in annual absolute rates of progress for other indicators. These thresholds for "real" are admittedly subjective and constructed mainly to avoid overestimating acceleration in cases where differences in rates of progress are extremely small. For context, a 0.33 difference in annual percentage point rates of progress leads to a cumulative 5 percentage point difference in outcomes

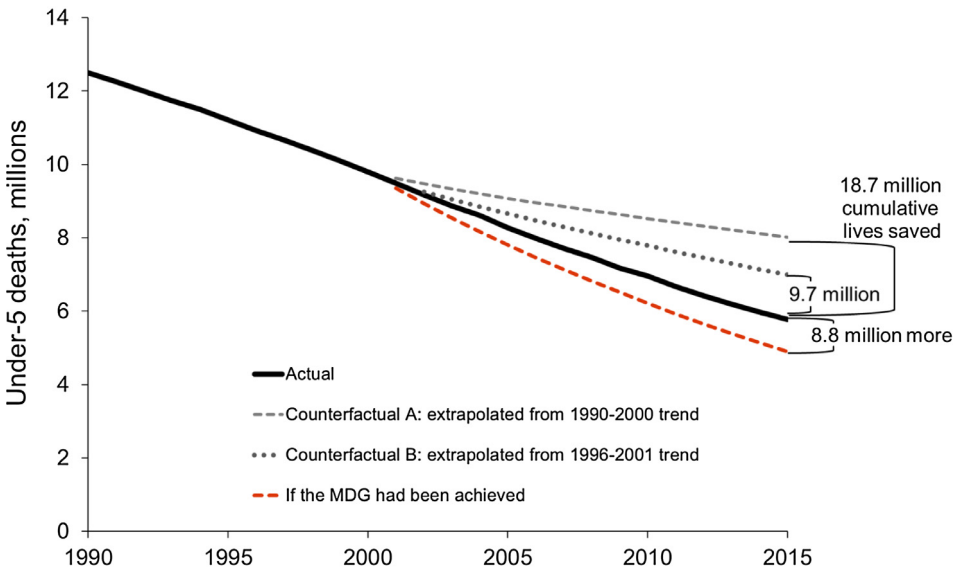

Fig. 3. Total deaths in children under-5 compared to business-as-usual trajectories, developing countries. *Source:* Authors' calculations based on U.N.-IGME (2017), UN Department of Economic and Population Division. (2017).

Table 1
Number of countries with any and "real" acceleration post-2000, by initial income group.

		Low-income countries					Middle-income countries				
			Any acceleration		"Real" acceleration			Any acceleration		"Real" acceleration	
Category	Indicator name	n	yes	%	yes	%	n	yes	%	yes	%
Life and death	Under-5 child mortality rate	65	58	89%	42	65%	90	37	41%	23	26%
	Estimated number of malaria deaths	51	25	49%	24	47%	9	5	56%	4	44%
	Maternal mortality ratio	65	46	71%	35	54%	82	31	38%	26	32%
	Antiretroviral therapy coverage	59	58	98%	57	97%	58	48	83%	46	79%
Basic needs	Access to improved water source	61	29	48%	11	18%	77	20	26%	1	1%
	Access to improved sanitation facilities	62	45	73%	11	18%	78	23	29%	1	1%
	Undernourishment, prevalence	55	36	65%	33	60%	37	23	62%	17	46%
	Primary school completion rate, both sexes (%)	40	30	75%	29	73%	39	22	56%	21	54%
	Gender parity index (GPI), gross enrollment ratio in primary	37	25	68%	20	54%	16	11	69%	6	38%
Extreme income poverty	Poverty head-count ratio at US$1.90 (2011 PPP)	11	6	55%	4	36%	25	17	68%	11	44%
Natural capital	Forest area	64	13	20%	3	5%	86	24	28%	3	3%
	Protected land area	65	37	57%	9	14%	90	39	43%	13	14%

Notes: (1) Sample includes up to 154 UN member states classified as low- or middle-income by the World Bank in 2000. (2) Child and maternal mortality and malaria deaths measured in annual proportional rates of progress; all other variables measured in percentage point rate of progress. (3) "Any acceleration": Yes if countries have positive acceleration toward the goal. Countries excluded from test if they are within 1 percentage point from the target as of 2000 (≥99% for water, sanitation, and primary completion rate; ≤6% undernourishment; ≥0.96 for GPI; and ≤1% for extreme income poverty). Countries excluded for malaria if they had <100 deaths in 2000. (4) "'Real' Acceleration": >1 percentage point annual acceleration for under-5 mortality, maternal mortality, and malaria, and >0.33 percentage point annual acceleration for other indicators. (5) Malaria deaths compares rates of progress from 2000–2005 versus 2005–2013. Antiretroviral therapy coverage compares rates of progress from 2000–2002 versus 2002–2015. *Sources:* Authors' calculations based on U.N.-IGME (2017), WHO (2016a), World Bank (2016b, 2017).

after 15 years. A sensitivity analysis shows that the results are not highly sensitive to variation in "real" acceleration thresholds (see Appendix for details).

For malaria deaths and antiretroviral therapy coverage, pre-2000 data is spotty or absent and requires an adjustment to the comparison years. We identify 2005 as a pivotal year for MDG-linked malaria efforts. This was when the U.N. Millennium Project presented its recommendation for mass distribution of long-lasting insecticide-treated nets and when the U.S. President's Malaria Initiative was subsequently launched on the eve of the Gleneagles G8 summit. We thus compare 2000–2005 with 2005–2013, the most recent year with data at the time of analysis. For antiretroviral therapy coverage, we attempt to capture the early stages of expanding access by comparing 2000–2002 with 2002–2015.

Acceleration in LICs was more common across indicators than in MICs. For child and maternal mortality, undernourishment, primary school completion, and gender parity in education, a majority of LICs with data recorded "real" acceleration. Among both income levels, there was widespread acceleration in access to HIV/AIDS treatment and primary school completion rates. In contrast, evidence of acceleration is less present for access to water and sanitation and measures of natural capital. Although the majority of LICs experienced some acceleration for sanitation and close to half experienced it for water, country-level acceleration was small and few countries passed the threshold for "real" acceleration. Forest cover had the least country-level acceleration, with 74 countries actually losing forest area between 2000 and 2015. Of those, 27 accelerated the rate of loss compared to pre-2000 trends.

4.3. Difference in mean rate of progress: t-tests

Table 2 synthesizes the results of *t*-tests organized by income group and geographic region. These compare unweighted average rates of progress between 1990–2000 and 2000–2015, with time periods adjusted as required by data constraints. Counterfactual B results comparing 1996–2001 and 2001–2015 are available in the Appendix. We do not conduct t-tests for TB deaths because of the high level of uncertainty in year-to-year country observations and many countries' death levels were estimated to be climbing during the early 2000s (WHO, 2017). Overall, LICs and Africa had significant average gains in their rates of progress across most indicators, while MICs had gains on only three indicators.

Building on the earlier description of results for child mortality trends, Table 2 shows that average country-level progress in reducing malaria deaths saw no significant acceleration between the two study periods (2000–2005 versus 2005–2013) even though the annual rate of decline in the overall number of malaria deaths accelerated. This is because acceleration was concentrated in countries with the largest number of malaria deaths. South Africa is an outlier in the data, and when that country is excluded from the test, the difference for the African sample becomes positive at 0.35, but is still not statistically significant.

For maternal mortality ratios, accelerations were concentrated in areas that started furthest behind. The average LIC increased its annual rate of progress from 2.1 percent before 2000 to 3.4 after 2000, significant at the 1 percent level, and by 0.6 percentage points between 1996–2001 and 2001–2015, although significant only at 10 percent levels. The average African country accelerated by more than 1 percentage point per year compared with both pre-MDG reference periods (1.7 percent to 2.8 for Counterfactual A and 1.7 percent to 2.8 for Counterfactual B). In contrast, the average country in Europe and Central Asia had no acceleration when compared to Counterfactual A and experienced a slowdown in progress from 5.2 percent to 3.6 when compared to Counterfactual B, significant at the 5 percent level. The Middle East and North Africa also showed evidence of slow-down during the 2000s, but there were no statistically significant changes in rates in other regions.

Nearly all geographies experienced substantial and significant accelerations in progress for access to antiretroviral therapy. As of 2000, only 8 then-developing countries—Argentina, Brazil, Costa Rica, Croatia, Czech Republic, Montenegro, Saudi Arabia, and Uruguay—are reported to have had more than 10 percent of HIV-infected people with access to treatment (World Bank, 2017). By 2015, 38 countries had at least 50 percent.

Overall, basic needs indicators had less acceleration than life and death indicators. For both access to water and access to

Table 2
T-test results – changes in average country rates of progress, 1990–2000 versus 2000–2015.

		n	All developing	Low-income	Middle-income	East Asia & Pacific	Europe & Central Asia	Latin America & Caribbean	Middle East & North Africa	South Asia	Sub-Saharan Africa
Life & Death	Child mortality	155	1.01***	2.42***	−0.01	0.11	1.69**	−0.84***	−0.77	0.90**	2.85***
			[0.24]	[0.33]	[0.30]	[0.63]	[0.62]	[0.29]	[0.51]	[0.29]	[0.42]
	Malaria deaths	60	0.19	0.19	0.20	1.29	n.a.	3.92	−0.82	2.83	−0.57
			[1.51]	[1.42]	[6.30]	[6.23]		[2.88]		[6.34]	[1.51]
	Maternal mortality	147	0.37	1.25***	−0.33	0.47	0.74	0.04	−1.71***	0.08	1.02**
			[0.28]	[0.29]	[0.42]	[0.60]	[0.74]	[0.76]	[0.48]	[1.25]	[0.43]
	Antiretroviral therapy	117	2.03***	2.59***	1.46***	2.85***	0.75	1.45***	1.26*	1.33	2.98***
			[0.26]	[0.18]	[0.48]	[0.43]	[1.23]	[0.49]	[0.68]	[0.70]	[0.21]
Basic Needs	Improved water	138	0.02	0.10***	−0.05***	0.06	0.11**	−0.10***	0.03	0.03	0.04
			[0.02]	[0.04]	[0.02]	[0.07]	[0.05]	[0.03]	[0.05]	[0.09]	[0.03]
	Improved sanitation	140	0.01	0.13***	−0.08***	0.05	0.07	−0.13***	−0.11*	0.08	0.08**
			[0.02]	[0.04]	[0.02]	[0.09]	[0.06]	[0.02]	[0.06]	[0.07]	[0.03]
	Undernourishment	92	0.37***	0.41**	0.30**	0.39	0.51	0.18	0.59*	0.45	0.37**
			[0.11]	[0.17]	[0.13]	[0.26]	[0.87]	[0.19]	[0.28]	[0.47]	[0.17]
	Primary school completion	79	0.64***	1.09***	0.18	0.83	0.23	−0.55	0.86	0.79	1.26***
			[0.21]	[0.33]	[0.25]	[0.60]	[0.42]	[0.31]	[0.56]	[0.72]	[0.40]
	Gender parity index, primary	53	0.58**	0.60*	0.54	0.32	0.88*	0.27	−0.21	2.74	0.48
			[0.25]	[0.31]	[0.45]	[0.18]	[0.12]	[0.15]	[0.25]	[1.97]	[0.29]
Income Poverty	Extreme income poverty	36	0.73**	0.99	0.62**	−0.25	1.59**	0.76*	−0.12	−0.13	0.46
			[0.29]	[0.76]	[0.26]	[0.19]	[0.59]	[0.43]		[0.40]	[1.07]
Natural Capital	Forest area	150	0.03	0.05*	0.01	0.00	0.07*	0.05	0.01	−0.01	0.02
			[0.02]	[0.03]	[0.03]	[0.10]	[0.04]	[0.04]	[0.01]	[0.12]	[0.02]
	Protected land area	155	−0.02	−0.04	−0.00	−0.28**	0.15	−0.16	−0.06	−0.29	0.16**
			[0.05]	[0.08]	[0.07]	[0.10]	[0.14]	[0.11]	[0.24]	[0.17]	[0.07]

Notes: (1) p-values: *<.1, **<.05, ***<.01. (2) Square brackets indicate standard error. (3) Middle East and North Africa has only one observation for malaria deaths and extreme income poverty, so no standard error is reported. (4) Child and maternal mortality and malaria deaths measured in annual proportional rates of progress; all other variables measured in percentage point rates of progress. (5) Malaria deaths compares rates of progress from 2000 to 2005 versus 2005–2013. Antiretroviral therapy coverage compares rates of progress from 2000 to 2002 versus 2002–2015. (6) Extreme income poverty results based on very limited available data. *Sources:* Authors' calculations based on U.N.-IGME (2017), WHO (2016a), World Bank (2016b, 2017).

sanitation, LICs accelerated average progress by approximately 0.1 percentage points per year – from 0.7 percentage points per year to 0.8 for water and 0.5 percentage points per year to 0.6 for sanitation. These differences are quantitatively modest but still statistically significant. MICs meanwhile registered small average slowdowns in access to water and access to sanitation, both significant at 1 percent levels. At the regional level, African countries experienced a small average acceleration on sanitation but no clear difference on water. Latin America and Caribbean countries experienced a small but statistically significant average slowdown for both water and sanitation, while in Europe and Central Asia the average rate of progress for water increased by 0.1 percentage points per year. Other regions had no clear shifts in trends. Both China and India achieved considerable overall gains on water and sanitation, but both also had slowdowns in their rates of progress on water after 2000.

For undernourishment, MICs, LICs, and African countries all showed positive shifts in average country rate of progress post-2000. LICs experienced the largest gains, with their average rate of progress increasing from 0.4 percentage points per year to 0.8 after 2000, the difference being statistically significant at 5 percent levels. African countries had a similar average acceleration from 0.3 percentage points per year to 0.6 after 2000, translating to an implied cumulative difference from BAU trends of 5.6 percentage points after 15 years. MICs also had a statistically significant average acceleration.

Developing countries registered significant overall accelerations in progress on universal primary school completion but less acceleration for gender parity in primary education. Across all countries with data, the average annual rate of progress in primary school completion approximately doubled post-2000, from 0.6 to 1.3 percentage points per year. Fig. 4 shows movements in the distribution of rates of progress across MICs, LICs, and Africa, respectively. As with other indicators, rates of progress in MICs had little acceleration from their typically higher starting primary completion values, while LICs and Africa experienced major acceleration. In Africa, the average country rate of progress in the 2000s was nearly five times what it was during the 1990s, accelerating from 0.3 percentage points per year to 1.6 after 2000. LICs' post-MDG rate of progress is more than three times as fast as pre-MDG rates.

For gender parity in primary education, the average rate of progress among 53 countries accelerated overall, but is not significant when disaggregated by income group or region. For extreme income poverty, the limited availability of country-level time series inhibits strong conclusions. However, there is some evidence of accelerated progress in both LICs and MICs, even if only statistically significant in the latter.

T-tests show almost no significant results for natural capital indicators. For forest cover, the subsamples for LICs and Europe and Central Asia showed very small positive differences, but significant only at 10 percent levels. For protected land area, only African countries showed a small positive and statistically significant average acceleration, while East Asia and the Pacific countries experienced a statistically significant slowdown.

As a final assessment of cross-country trends, we conducted regressions to explore the relationship between initial indicator levels and subsequent rates of progress, as a complement to the similar test mentioned earlier for child mortality. Full results are listed in the Appendix. For maternal mortality, countries with higher rates of initial mortality experienced slower (with statistical significance) average rates of progress during the period 1996–2001, but not over any of the other relevant periods. For access to antiretroviral therapy, countries with lower initial access have higher average rates of progress during the period 2002–2015. For malaria deaths and protected land area, we find no statistically significant links between initial values and subsequent rate of progress. For access to water, sanitation, nourishment, primary school completion, gender parity index in primary enrollment, and forest cover, we find that countries with higher (better) initial indicator values have slower average subsequent rates of progress. However, for sanitation and pre-2000 values of primary school completion and gender parity, we find the negative correlation does not hold when the sample is restricted only to countries with starting values of 0.90 or less.

4.4. Total lives saved and improved

We next consider the absolute human implications of changing trends, looking first at life and death indicators. To establish a range of cumulative lives saved during the MDG period, we sum the number of incremental child, maternal, TB-infected, and HIV-infected lives saved, compared to pre-MDG trajectories. Summary results are presented in Table 3. (See Appendix for full regional results.) Where possible, estimates of lives saved are presented as falling within a range. This should not be interpreted as a statistical confidence interval, but instead as a range of point estimates based on differing methodological assumptions. Note that there is limited overlap between the categories of deaths. WHO reports non-HIV-related TB deaths, which allows us to assess the two diseases separately. The minor exception is HIV/AIDS, for which less than 3 percent of deaths in 2002 were estimated to be among children under 5 (based on WHO (2016a)). We scale down the HIV/AIDS figures in Table 3 accordingly.

By summing up across categories, and recognizing the different counterfactual scenarios considered for each, we estimate a total of 20.9 million to 30.3 million incremental lives saved. Improvements in child survival were a lead driver of overall lives saved. As indicated in Section 4.1, an incremental 9.7–18.7 million children survived to their fifth birthday during the MDG era. Africa accounted

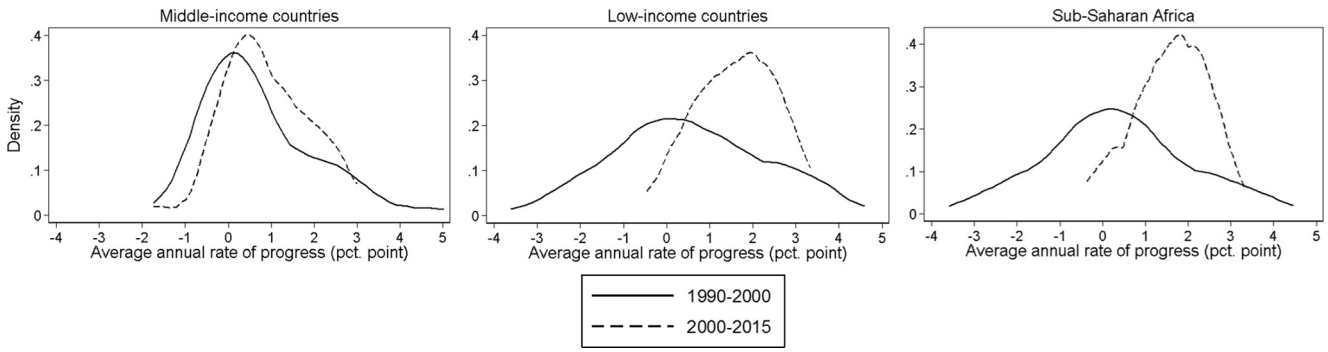

Fig. 4. Distribution of annual rates of progress in primary school completion, 1990–2000 versus 2000–2015. *Notes:* 39 middle-income countries; 40 low-income countries; 30 sub-Saharan African countries. Calculated using Epanechnikov kernel with optimal band-width. *Source:* Authors' calculations based on World Bank (2017).

Table 3
Cumulative lives saved between 2000/2001 and 2015 due to accelerated progress (millions).

		Geography				Income Group	
	All developing	China	India	Sub-Saharan Africa	Rest of developing world	Low-income ex. India	Middle-income ex. China
Child mortality	9.7–18.7	0.9–1.9	1.3–2.4	7.5–13.5	(0.1)–0.9	7.1–14.1	0.3
Maternal mortality	0.4–0.7	(0.003)–0.007	0.03–0.1	0.3–0.5	0.04–0.05	0.4–0.6	(0.01)–0.01
Tuberculosis deaths	3.2	0.6	1.1	0.03	1.5	1.1	0.4
HIV/AIDS deaths	7.7	0.2	0.5	6.0	1.0	4.3	2.8
TOTAL LIVES SAVED	20.9–30.3	1.8–2.7	2.9–4.1	13.8–20.1	2.5–3.4	12.8–20.1	3.4–3.5

Notes: (1) Calculations based on extrapolations of pre-MDG trends compared to actual values from 2001–2015. (2) Parentheses denote negative (fewer) lives saved compared to trend. (3) Child and maternal morality ranges based on Counterfactual A (trend extrapolated from 1990–2000) and Counterfactual B (trend extrapolated from 1996–2001). (4) Values for TB assume deaths in each country remained constant from 2001 onward. (5) HIV/AIDS based on estimated deaths averted due to antiretroviral therapy (ART), with disaggregation weighted by distribution of people with access to ART. *Sources:* Authors' calculations based on U.N.-IGME (2017), World Bank (2017), WHO (2017), UNAIDS (2016, 2017), UN-DESA (2017).

for more than 70 percent of global gains in child survival, with 7.5 million to 13.5 million incremental lives saved. The top global contributors to the incremental child survival gains were Nigeria (1.1 million to 2.6 million estimated lives), India (1.3 million to 2.4 million), China (0.9 million to 1.9 million), Uganda (1.0 million to 1.5 million), and Angola (0.5 million to 0.9 million). Overall, a clear majority of lives saved occurred in LICs, even when excluding India.

We consider malaria as a subcategory embedded within the number of children's lives saved, since a considerable majority of malaria deaths occur among children under the age of 5. Estimated malaria deaths are not reported annually, so it is not possible to estimate cumulative lives saved compared with pre-2005 counterfactuals. However, if trends from 2000 to 2005 had continued, there would have been approximately 180,000 additional deaths in 2013, the most recent year with data. We estimate that progress on malaria accounted for roughly a tenth of the under-5 children's lives saved in 2013.

Maternal mortality follows a similar geographic pattern as child mortality, although on a smaller scale due to the lower initial number of maternal deaths. Compared with Counterfactual A, approximately 657,000 additional maternal deaths would have occurred between 2001 and 2015 had BAU persisted and 400,000 under Counterfactual B. Again, the majority of deaths averted occurred in Africa and LICs, even when excluding India.

For TB, because of problems with pre-2000 data quality and the high level of uncertainty in year-to-year country observation, we calculate only one counterfactual, which assumes that each country's annual number of deaths to the disease remained constant from 2001 onward. This is a conservative assumption because many countries' death levels were estimated to be climbing during the late 1990s and early 2000s (WHO, 2016b). The calculation suggests that approximately 3.2 million lives were saved cumulatively from 2002 to 2015. Roughly 1.5 million of these occurred in developing countries outside of China and India.

Success on HIV/AIDS accounts for the second largest number of estimated lives saved. The Joint United Nations Programme on HIV/AIDS (UNAIDS) estimates that 7.9 million HIV-related deaths were averted due to access to treatment between 2000 and 2015 (UNAIDS, 2017). We use this number to estimate lives saved for each country, with disaggregation weighted by the distribution of people with access to ART in 2015 (See Appendix for a more detailed methodology).

Table 4 presents estimates of lives improved across basic needs and income poverty indicators. Note that the numbers of lives improved should not be added across issue indicators here, because of likely overlap among populations.

The consistent rates of progress for water and sanitation generated modest results for estimates of incremental lives improved, compared with BAU. For water, approximately 100 million fewer lives were improved than if trajectories from 1990 to 2000 had continued, with China and India responsible for much of that figure. Meanwhile Africa achieved a positive net increment of 3 million people with access, but this is not materially different from zero when compared with the region's population of approximately 1 billion in 2015.

Slightly more lives are estimated to have been improved by accelerated gains on sanitation. Overall nearly 19 million more people were estimated to have access compared with BAU trends, including modest positive increments in China, India, and Africa. As

Table 4
Millions of lives improved – or not – as of 2015 (or most recent available year) due to accelerated progress since 2000.

		Geography				Income Group	
	All developing	China	India	Sub-Saharan Africa	Rest of developing world	Low-income ex. India	Middle-income ex. China
Improved water	(100)	(63)	(22)	3	(18)	(2)	(13)
Improved sanitation	19	10	10	17	(19)	25	(28)
Undernourishment	(166)–(98)	(60)–(4)	(123)–(80)	(13)–4	(1)–13	n.a.	n.a.
Primary school completed	74–111	n.a.	n.a.	18–29	n.a.	n.a.	n.a.
Extreme income poverty	471–610	(22)–157	199–225	102–150	119–152	n.a.	n.a.

Notes: (1) Calculations based on extrapolations of pre-MDG trends compared to actual values up to 2015. (2) Parentheses denote negative (fewer) lives saved compared to trend. (3) Totals for water and sanitation based on country-level extrapolation from approximately 1990–2000/2001. (4) Ranges for undernourishment and primary school completed based on Counterfactual A (trends extrapolated from 1990/1991–2000) and Counterfactual B (extrapolated from 1996–2001) using World Bank regional and developing country aggregates, as classified in 2017. (5) Primary school completed is a sum of all additional students who have completed primary school between 2001 and 2014. (6) Ranges for extreme income poverty based on Counterfactual A (trends extrapolated from 1990–2002) and Counterfactual B (extrapolated from 1996–2002) using World Bank regional and developing country aggregates. (7) "n.a." indicates data not available for calculation. *Sources:* Authors' calculations based on World Bank (2016a, 2017), UN-DESA (2017).

a group, LICs excluding India achieved a net positive increment of 25 million people, equivalent to roughly 1.3 percent of the relevant population, while MICs excluding China had a net negative increment of 28 million, equivalent to around 1.6 percent of that group's population.

For undernourishment, although many developing countries experienced post-2000 acceleration in rates of progress, 30 countries experienced deceleration, including China and India and several other populous countries. The overall result is approximately 98 million to 166 million additional people undernourished compared with what would have been the case if constant annual progress had continued. If China had remained on its 1990s trajectory, 4 million to 60 million fewer people would be undernourished as of 2015. If India had continued on its 1990s trajectory, 80 million to 123 million fewer people would be undernourished in 2015. When these two countries are excluded from the calculation, the net number of incremental lives improved ranges from negative 14 million to positive 17 million—in other words, indistinguishable from zero.

For primary education, acceleration in rates of progress led to an estimated 74 million to 111 million more people completing primary school between 2000 and 2014 (the most recent year with available data) than would have under pre-MDG trajectories. In Africa, this corresponding outcome is between 18 million and 29 million additional people, roughly a quarter of the global total. Of course, the extent to which primary school completion rates affected learning outcomes is an important separate question that lies beyond the scope of this paper.

When calculating the number of incremental people lifted out of extreme poverty, we use slight variations on the pre-MDG reference dates due to World Bank reporting years. Counterfactuals are based on rates of change in aggregate head-count poverty ratios from 1990 to 2002 and 1996 to 2002, respectively. This highly simplified counterfactual method implies that somewhere in the range of 471 million to 610 million more people were living above the extreme poverty line than would have been the case under previous trajectories. This includes approximately 254 million to 268 million people outside of China and India. When excluding China and India from the equation, the rest of the developing world likely cut extreme poverty from approximately 32 percent in 1991 to 15 percent in 2013.

4.5. Acceleration versus progress

For an overall distillation of patterns of progress, we return to the guiding logic described at the outset in Fig. 1. For each MDG target, outcomes should ultimately be considered based on both the amount and acceleration of progress. To this end, Fig. 5 synthesizes population or birth-weighted results for low-income countries (excluding India) and middle-income countries (excluding China). The horizontal axis indicates the share of each problem that was eliminated within the respective geography between 1990 and 2015. Each group's baseline gap (e.g., percentage without water, dying before fifth birthday, and so forth) is indexed to a value of 100, recognizing that MDG targets generally aimed to reduce each problem by 50 percent or more. To illustrate, if a population had 50 percent without access to water in 1990 and 30 percent without access in 2015, this is counted as a 40 percent reduction in the problem. The vertical axis then indicates the degree of acceleration in the proportional rate of progress pre- and post-MDGs. A ratio of 1 implies no change in the rate of progress, while a ratio of 2 implies a doubling in the rate of progress, and so forth. (Equivalent graphs based on absolute percentage point rates of progress are included in the Appendix.)

Fig. 5 shows that much of the world's acceleration in progress occurred in LICs (outside of India), while MICs and the rest of the world (outside of China) typically had larger gains but less acceleration. Among the relevant indicators presented, the share of the problem eliminated ranged from 21 percent for sanitation in LICs to 62 percent for water and child mortality in MICs. In this figure, we are only able to calculate income group estimates for four indicators—child mortality rates, maternal mortality rates, water, and sanitation—because of limited country-level data availability.

Figures showing comparable results for China, India, and other geographic aggregates are included in the Appendix. Notably, the LICs, Africa, Europe and Central Asia, and China all experienced more than a doubling of their post-2000 birth-weighted rate of progress on child mortality, with Africa accelerating its aggregate

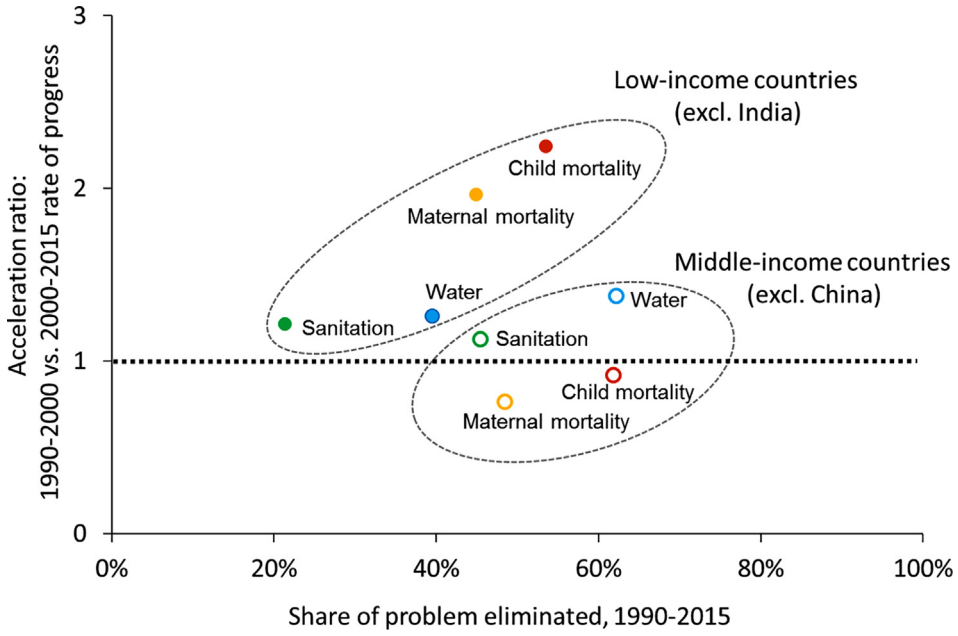

Fig. 5. Acceleration versus progress during the MDG era, by initial income group. *Note:* Child and maternal mortality results are weighted by total births in each country; water and sanitation results are weighted by total population in each country. *Sources:* Authors' calculations based on U.N.-IGME (2017), World Bank (2017), UN-DESA (2017).

rate of progress by a factor of 2.8. Also notable is the dramatic acceleration of Africa's primary school completion rates, on which progress accelerated more than 50-fold post-2000, and gender parity in primary education, on which the region tripled its rate of progress. In comparison, Latin America and the Caribbean reduced child mortality by 67 percent, but with a slowdown compared to its previous fast rate of progress during the 1990s. Across geographies, sanitation was commonly the indicator lagging the furthest behind.

5. Conclusion

This paper's results highlight the 2015 outcomes that were or were not on track to happen as of 2000. The clearest shifts in trends occurred in the poorest countries in the realm of life and death issues—most notably child mortality, maternal mortality, and infectious diseases including AIDS and TB. Many of those same countries, especially in Africa, had by far the greatest accelerations in rates of progress. Low-income countries outside of India accounted for more than three-fifths of the estimated range of 20.9 million to 30.3 million incremental lives saved overall. China and India together accounted for less than a quarter of the overall additional lives saved due to acceleration.

The results for basic needs indicators are more nuanced. The developing world was already making steady aggregate gains on such issues as undernourishment and access to drinking water prior to the establishment of the MDGs, and these trends continued at a generally consistent rate. However, what did change for these issues was an apparent average acceleration in the rate of progress across low-income countries and African countries, even if not always in the most populous countries.

A positive standout among basic needs indicators was primary school completion, on which developing countries are estimated to have experienced a 0.6 percentage point faster average rate of progress after 2000. Meanwhile, gender parity in primary education accelerated in a majority of relevant countries. The clear laggard among basic needs indicators was sanitation, which generally continued slow progress in LICs, even if accompanied by a modest acceleration. The world is not yet on course to solve the global sanitation problem anytime soon.

We consider extreme income poverty as a separate analytical category. Although this indicator is subject to complex measurement dynamics, available data suggest a mixed pattern of acceleration trends across geographies, still leading to an overall estimate of 471 million to 610 million additional people living above the global extreme poverty line compared to pre-MDG trends. The clearest shortcomings during the MDG era were in the realm of environmental sustainability. There was little overall progress on proxy indicators such as forest cover and protected land area, suggesting the 2010 target for biodiversity loss did not succeed.

Our analysis draws attention to issues of data quality and availability. In attempting to assess trends during the MDG era, we found that many key observations are missing, many are likely subject to measurement error, and many will likely be revised in coming years. All of this motivates a considerable degree of caution not to interpret any of our results with false precision. They are presented only as best estimates given the information available. Jacob (2017) offers evidence suggesting that data gaps contribute to slower rates of progress. This would only amplify the clear need for a "data revolution."

The variation in outcomes during the MDG era prompts a question of why—what drove the differences? If one presumes, for example, that economic growth is the primary driver of outcomes, then one would need to substantiate how the same underlying patterns of growth led to such different trends across outcomes such as HIV/AIDS deaths, child mortality, primary school completion, and access to drinking water. Similarly, a hypothesis that commodity prices drove gains among low-income exporting economies would need to identify the pathways between commodity-specific price trends and the cross-section of relevant MDG indicator outcomes. Conversely, if one believes that official development assistance is a primary driver of specific results in low-income environments, then one would need to substantiate the links between issue-specific outcomes and relevant forms of public and private finance.

Importantly, the diversity of outcomes across sectors draws attention to issues that are less prone to statistical analysis, including institutional designs and epistemic norms among different policy communities. The field of global health, for example, has undergone a major expansion of delivery-oriented international public institutions such as the Gavi Alliance; the Global Fund to Fight AIDS, Tuberculosis, and Malaria; the U.S. President's Emergency Plan for AIDS Relief; and the U.S. President's Malaria Initiative. The field has also benefited from a surge in private philanthropy over the past two decades, some of which has been used to boost investments in applied research, which frequently assesses progress on the goals in prestigious academic journals like The Lancet (McArthur & Zhang, 2015). For policy communities that have had less notable accelerations, such as for undernourishment or sanitation, questions need to be raised regarding which institutions are taking responsibility for which outcomes, and even which top-tier journals are convening the applied research debates to inform progress.

The results further prompt questions around inherently complex notions of public responsibility. When the world sets goals like the MDGs—or now the SDGs—who is responsible for each component that feeds into progress, ranging from research to evaluation to advocacy to financing to policy design to implementation? Who should be celebrated when complex systems generate unprecedented outcomes? Who should be accountable when populations fall short? Who should be held responsible for the adequacy of data even to assess progress?

Such questions of causality and accountability ultimately lie beyond the scope of this study. But the paper's results nonetheless help inform assessments of how and where the world's patterns of progress changed during the MDG era. Some of the shifts were dramatic. Learning from them is crucial for generating the world's next batch of needed breakthroughs.

Conflict of interest

The authors have no conflict of interest in preparing this paper.

Disclosure

From 2002 to 2006, the first author was manager and then deputy director of the UN Millennium Project, Secretary-General Kofi Annan's independent policy advisory body mandated to recommend an action plan for achieving the Millennium Development Goals. Against that backdrop, this paper aims to conduct a fully independent analysis of relevant global trends.

Role of the funding source

The authors are both employees of the Brookings Institution. Brookings recognizes that the value it provides is in its absolute commitment to quality, independence and impact. Activities supported by its donors reflect this commitment and the analysis and recommendations are not determined or influenced by any donation. A full list of contributors to the Brookings Institution can be found in the Annual Report at https://www.brookings.edu/about-us/annual-report.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.worlddev.2017.12.030.

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