

# How the New International Goal for Child Mortality Is Unfair to Africa (Again)

**Simon Lange and Stephan Klasen**

## Abstract

Despite unprecedented progress towards lower under-five mortality in high-mortality countries in recent years, a large fraction of these countries will not attain the numerical target under Millennium Development Goal (MDG) 4, a reduction of the mortality rate by two-thirds compared to levels in 1990. Nevertheless, many stakeholders have argued that the post-2015 agenda should contain a level-end goal for under-five mortality and recent accelerations in the rate of reduction in under-five mortality have been cited as a cause for optimism. We argue in this paper that one key fact about relative changes in mortality rates is a lack of persistence. We find robust evidence for substantial mean reversion in the data. Hence, recent accelerations observed for countries in Sub-Saharan Africa are an overly optimistic estimate of future reductions. At the same time, progress as required by the old MDG4 coincides very much with our projections for Sub-Saharan Africa and other regions. Thus, while MDG4 has been rightly criticized as overly ambitious and unfair to Africa for the 1990-2015 period, such a goal seems more appropriate for the 2005-2030 period. We also offer a discussion of likely drivers of future reductions in child deaths.

**JEL Codes:** I15, I18, J11, J18, O21

**Keywords:** MDGs, SDGs, under-five mortality, Africa.

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# 1 Introduction

Even if the health MDGs will not be met in all countries by 2015, the gains point the way to further dramatic reductions in the number of deaths [...]. The MDG health targets need to be retained, updated, and expanded. Preventable child deaths [...] should be ended by 2030.

[Sustainable Development Solutions Network \(2014\)](#)

[...] with the right investments, the stark differences in [...] child death rates between countries of differing income levels could be brought to an end within our lifetimes. Economic growth in many low-income and middle-income countries and the increasing availability of high-impact health technologies make a grand convergence in health achievable by 2035.

[Lancet Commission on Investing in Health \(2013\)](#)

The Millennium Development Goals (MDGs) have been a great success in encouraging development. The Millennium Declaration, from which the MDGs derived, represents an unprecedented consensus among world leaders. As a comprehensive list of goals and targets, most of which were supplemented with indicators and a target date for completion, the MDGs have helped focus debates on some of the most pressing challenges facing humankind and have served as a highly effective advocacy tool for those concerned with improving the lives of the poor ([Manning, 2010](#); [Klasen, 2012](#)).

The fourth MDG, a call to reduce the rate of under-five mortality by two-thirds relative to levels in 1990 until the end of this year, has received much attention and many countries, particularly in Sub-Saharan Africa, have made exceptional progress towards this goal. Nevertheless, a large fraction of these countries are unlikely to attain this goal and some commentators have argued that MDG4, among other goals, was biased against developing countries and Sub-Saharan Africa in particular ([Clemens, 2004](#); [Clemens et al., 2007](#); [Easterly, 2009](#); [Klasen and Lange, 2012](#)).

Nevertheless, recent proposals for the Sustainable Development Goals (SDGs) call for replacing the target defined in relative terms and turn to a global minimum standard, a level-end goal to be attained in 15 to 20 years from now—see table 1 which we adopted from [Verguet et al. \(2014\)](#). Most prominently, the UN Secretary General’s [High-Level Panel of Eminent Persons \(2013, p. 30\)](#) has called for an end to preventable infant and under-five deaths by 2030 and has defined this as an under-five mortality rate below 20 per 1,000. The UN’s [Open Working Group \(2014\)](#) that negotiated in 2014 a new system of SDGs calls for ending preventable deaths of newborns and children under five years of age with indicators yet to be set. However, those are likely to be similar to the rates reported in table 1. Both the United Nations’ [Sustainable Development Solutions Network \(2014\)](#) and the [Lancet Commission on Investing in Health \(2013\)](#) have

Table 1: Selected proposals for post-2015 global health targets.

	The Lancet Commission on Investing in Health <sup>1</sup>	Global Investment Framework for Women’s and Children’s Health <sup>2</sup>	UNICEF <sup>3</sup>	Sustainable Development Solutions Network <sup>4</sup>	High-Level Panel of Eminent Persons on the post-2015 Development Agenda <sup>5</sup>
Timeframe	2035	2035	2035	2030	2030
Under-five mortality deaths	16 (interim target of 20 by 2030)	39 in low-, 22 in low-to-middle-income countries.	$\leq 20$	$\leq 20$	$\leq 20$

Adopted from Verguet et al. (2014).

<sup>1</sup> Lancet Commission on Investing in Health (2013).

<sup>2</sup> Global Investment Framework for Women’s and Children’s Health (2014).

<sup>3</sup> UNICEF (2013).

<sup>4</sup> United Nations Sustainable Development Solutions Network (2014).

<sup>5</sup> High-Level Panel of Eminent Persons (2013).

adopted the same target, the latter claiming that “a ‘grand convergence’ in health is achievable within our lifetimes”—by which they mean the year 2035. Others have been slightly more careful but have also set level-end targets that seem ambitious for high-mortality countries (e.g. [Global Investment Framework for Women’s and Children’s Health, 2014](#); [UNICEF, 2013](#)).

Claims that the new goal is feasible—such as the epigraphs above—have been backed sometimes by costing studies that try to assess what kind of resources it would take to attain the new health target ([Boyle et al., 2014](#); [Global Investment Framework for Women’s and Children’s Health, 2014](#)). Costing studies have also been conducted following the birth of the MDGs (e.g. [High-level Panel on Financing Development, 2001](#); [Devarajan et al., 2002](#)). However, it is widely understood that these studies are very crude, abstract from institutional constraints in developing countries, and are easily misinterpreted and sometimes misused ([Clemens et al., 2007](#); [Klasen, 2012](#)).

In other cases, backing came through empirical assessments. [Verguet et al. \(2014\)](#) project under-five mortality rates in 2030 based on current annual rates of reduction (ARRs) over five years or ‘aspirational’ ARR observed in recent years. The latter were calculated as the 90th percentile for all countries of ARR, which turned out to be between five and 8.3 percent. They estimate that between 50 and 64 percent of countries in their sample would achieve this target by 2030. [McArthur \(2014\)](#) bases projections on twelve-year ARR and finds that 135 countries are on-track to achieve an under-five mortality rate of 30 or lower by 2030 while 38 are not.

In this paper, we show that the above-cited empirical assessments are flawed. Our main point is that ARRs in under-five mortality rates exhibit considerable mean reversion. Therefore, current ARRs are not adequate estimates for future rates. The resulting geographical distribution of projections until 2030 changes considerably with a clear disadvantage for countries in Sub-Saharan Africa. At the same time, a ‘re-newed’ MDG4—a call for a reduction in under-five mortality rates by two-thirds between 2005 and 2030—results in target rates that are ambitious yet well in reach for nearly all countries.

We also highlight future challenges that need to be overcome in order to further bring down under-five mortality in Sub-Saharan Africa. Economic growth plays a role and high growth rates over the last decade have helped. However, it seems questionable whether high levels of growth can be sustained over the next years. Finally, we will argue that future health interventions will differ considerably from those that were required to bring about the progress we have seen in recent years. Making further inroads will become increasingly more difficult as the focus shifts from low-cost, readily-implementable interventions to policies to improve service delivery and up-take more broadly.

Finding the right trade-off between realism, simplicity, and ambition in setting development goals is of great importance. Unrealistic targets may jeopardize the broad public support the MDG process has received in the past and may cause ‘aid-fatigue’ in donor countries once it becomes clear that many developing countries will not attain them (Easterly, 2009). There is also some evidence that realistic targets induce effort from governments, at least if incentives are in place (Öhler et al., 2012). Simplicity, on the other hand, has been important for the MDGs’ success as a communication tool and the same is true for ambition. Finally, targets for the post-2015 period should be applicable to all countries in order to ensure broad buy-in.

Particular care should be applied in deriving an international development goal for under-five mortality. The child mortality-goal has received much attention in the past, most likely because it is of obvious relevance and easy to understand. Conceptually, it has several advantages over alternatives: first, survival is, for all practical purposes, an actual ‘end of development’ and a necessary requirement for achieving other capabilities that we have reason to value (Sen, 1998). Second, mortality rates complement records on economic growth as they are responsive to changes in inequality in access to basic services and commodities (ibid.)<sup>1</sup> Finally, under-five mortality is easily measured and the data are widely believed to be of reasonable quality,<sup>2</sup> While this may seem trivial, it is not the case for many other MDG indicators (Attaran, 2005), particularly for those related to health: indicators of food insecurity and undernutrition have been widely criticized (Svedberg, 2002; de Haen et al., 2011). Data on maternal mortality are estimated from regression-based models that rely on auxiliary variables such as fertility rates and GNI per

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<sup>1</sup>Sen (1987) and Drèze and Sen (1989) present data from the UK showing that improvements in life expectancy occurred in decades of slow growth, particularly the war decades, a consequence of improvements in the access to food and public health services and the introduction of the National Health Service in the 1940s.

<sup>2</sup>This is largely the result of an increasing number of comparable cross-country surveys, the Demographic and Health Surveys, that include questions directed at women of child-bearing age about their actual birth histories and thus allow the estimation of mortality rates for children even in the absence of vital registration systems.

Table 2: ARRAs (in percent) and initial levels of under-five mortality (deaths per 1,000 live births) in developing countries, 1960–2010.

	ARRAs					Initial levels	
	1960s	1970s	1980s	1990s	2000s	1990s	2000s
East Asia & Pacific		4.32	2.84	3.12	6.16	59.0	41.9
Europe & Central Asia			4.18	2.25	4.83	55.7	42.3
Latin America & Caribbean	3.20	3.31	4.41	5.12	4.73	55.1	32.8
Middle East & North Africa	1.98	4.86	6.78	3.93	4.84	67.4	44.9
South Asia	1.57	2.11	2.77	3.12	3.83	129.4	94.0
Sub-Saharan Africa		2.26	1.23	1.19	4.13	179.0	156.0

Based on region aggregates from the World Development Indicators 2014.

capita. Different models have led to stark differences, particularly in trends ([AbouZahr, 2011](#)).

The paper is organized as follows: the next section reviews recent trends and their relationship to levels and compares these to MDG4. We relate this to the discussion surrounding the appropriateness of the MDGs. The main point is that ARRAs have seen a large acceleration during the last decade in some of the high-mortality countries but many are nevertheless not on-track to attain MDG4. This is in part due to the inappropriateness of the numerical target which, however, looks more appropriate today. Section 3 establishes that there is a substantial degree of mean reversion in ARRAs. The consequences of this are further explored in section 4 in which we make projections based on a model that accounts for mean reversion and compare results to projections based on current ARRAs. We also compare our projections to target mortality rates that would result from a re-renewal of MDG4. Section 5 discusses further issues that are important in trying to gauge the prospects of high-mortality countries in Africa of attaining the new target. Section 6 concludes.

## 2 Recent performance and the trouble with the MDGs

We obtain average ARRAs over five and ten years from ordinary least squares (OLS)-regressions of log mortality rates on years for different time periods. Note that a greater number implies more rapid progress. The data come from the World Bank’s World Development Indicators 2014.

Many developing countries, particularly in Africa, have made rapid progress towards MDG4. Table 2 reports ten year-ARRAs for under-five mortality for the past five decades and levels in 1990 and 2000. All figures are calculated from regional aggregates for developing countries from the World Development Indicators 2014. The ARRAs observed during the 2000s are greater than those for the 1990s in all regions except Latin America and the Caribbean. They have more than tripled in Africa. This has been noted elsewhere. For instance, a recent review of long-term trends in under-5 mortality synthesizing a wide variety of data ([Rajaratnam et al., 2010](#)) finds that rates of reduction have increased in 34 countries in Sub-Saharan Africa for 2000–2010

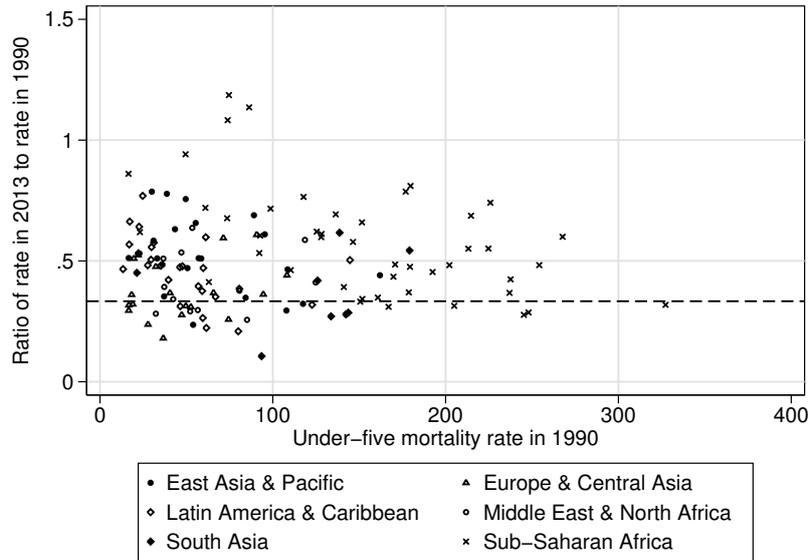


Figure 1: Ratio of under-five mortality rate in 2013 to 1990 against rate in 1990. Own calculations based on data from the World Development Indicators 2014.

compared with 1990–2000 and have increased by one percent or more in 13 countries.

At the same time, it has been noted that many developing countries will not attain MDG4 and that it may have been unrealistic to assume they would in the first place. The first point is illustrated in figure 1 which plots ratios of rates in 2013 to those in 1990 against initial levels. We also indicate the 2015 MDG4-target through the horizontal dashed line that indicates a reduction by two-thirds and implies an ARR of 4.3 percent between 1990 and 2015. While there are two years left for countries to cross the line, it is clear that many countries will fail to do so. By 2013, only three out of 22 countries in East Asia had attained the goal and only six out of 45 in Sub-Saharan Africa. The best-performing region by this measure was South Asia in which exactly half of the eight countries had attained the goal already.

It is important to note that while the MDGs are frequently interpreted as country-specific goals, they were not conceived in this way. After agreeing on 1990 as the benchmark year, the MDG4 target and others were arrived at by linearly extrapolating from global trends (Vandemoortele, 2009). Thus, the MDGs were to be reached at the global level rather than at the country-level and relied on data from an episode that saw large declines in under-five mortality in the developing world, particularly in Sub-Saharan Africa.

Nevertheless, for lack of further coordination between actors as to how much each country would have to contribute in order to attain MDG4, the numerical target was frequently interpreted as a national policy goal. National governments, NGOs, and even UN agencies frequently compare progress to the required rate for individual countries. The Global Monitoring Reports

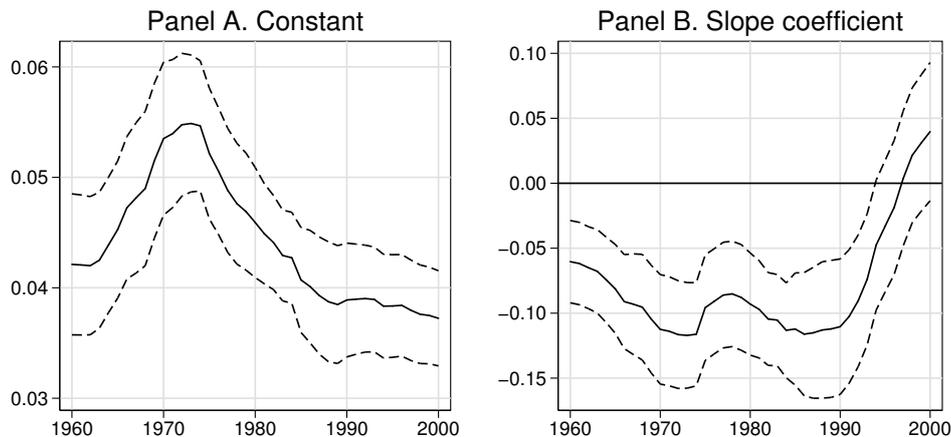


Figure 2: Estimated constant and slope coefficient from a regression of ARR over ten years against initial levels, 1960–2003. Dashed lines indicate 95-percent-confidence intervals. Own calculations based on data from the World Development Indicators 2014.

similarly discuss progress at the country-level (e.g. [World Bank, 2011](#)). It seems very likely that future development goals will equally be interpreted at the country-level as there is much demand for local actors for a yardstick against which to compare their country’s progress. It is thus reasonable to contend that future development goals *should explicitly be country-specific*.

If one accepts that stakeholders compared their country’s progress against global targets set by the MDGs, two problems immediately become apparent. The first is that the 1990s were in many ways a ‘lost decade’ for mortality reductions in many developing countries ([Easterly, 2009](#)). This is particularly true for Africa where countries experienced declining aid budgets, civil strife, the onset of high mortality associated with the HIV/AIDS epidemic, and often a combination of these factors. The result were low ARR for these countries during the 1990s which are also evident in table 2. As this was clear by the end of the decade when the MDG targets were conceived, choosing 1990 as the base year dimmed Africa’s prospects of attaining MDG4.

The second reason is more subtle: for most of the second part of the last century for which data are available there was a negative relationship between ARR and initial levels in under-five mortality. High-mortality countries made less progress in relative terms (but more in absolute terms). We can illustrate this point by estimating OLS regressions of ARR over ten years against initial under-five mortality rates (in percent) for each year in the dataset for which this is possible (i.e. 1960–2003) and including developed and developing countries.<sup>3</sup> Figure 2 illustrates the evolution of the constant (panel A) and the slope coefficient (panel B) from this regression over time and 95-percent-confidence bands (dashed lines). The constant is always positive and

<sup>3</sup>The number of countries changes over time but the overall picture remains unchanged when we restrict the sample to 107 countries for which we have data for all years.

significantly different from zero. Low-mortality countries—countries that have mortality rates close to zero—have seen ARR of 3.5–4.5 percent on average with a slight uptick during the early 1970s. ARRs were lower for high-mortality countries for most of the time: between 1960 and 1990, a ten-percentage point higher mortality rate (e.g. going from 100 per 1,000 to 200 per 1,000) was associated with roughly a tenth of a percentage point lower ARR over the subsequent ten years and this relationship was significant at the five-percent level. The slope coefficient increased after 1990 and turned insignificant in 1995.<sup>4</sup>

This indicates that relative changes would have been inappropriate as a target in the past and this is also true for the MDGs which defined 1990 as the relevant baseline year. It may be appropriate now, but this option no longer seems to be on the table. We will come back to this point in section 4. It is unclear, however, why the link between initial mortality rates and the ARR broke down in recent years. Theory suggests that ARRs increase in initial levels and, hence, with progress over time (Klasen and Lange, 2012) and that countries with adverse natural disease environments have lower ARRs (Strulik, 2008). It is therefore conceivable that the 2000s have been an exceptional episode for high-mortality countries caused by high rates of economic growth, increasing aid levels, and a recovery from HIV/AIDS-related mortality and civil strife.

### 3 Mean reversion models

If the 2000s were an exceptionally good decade for mortality reductions in Africa, mean reversion would imply that progress is likely to slow in the future. In this section we investigate this issue empirically. Mean reversion (or *regression toward the mean*) is the statistical phenomenon by which random variation in time series data may appear to be a meaningful empirical fact. Its manifestation are unusually large or small measurements that tend to be followed by measurements closer to the mean (e.g. Barnett et al., 2005). Mean reversion gives rise to several fallacies such as the *Sports Illustrated Cover Jinx* (the notion that teams or athletes that appear on the cover of the *Sports Illustrated* magazine will subsequently experience bad luck) and, similarly, the *Sophomore Slump* (the notion that the “rookie of the year” does less well during the subsequent season) (Schall and Smith, 2000). More significantly, it sometimes leads to the adaptation of detrimental behaviors and politics (e.g. the apparent empirical finding that rebukes seem to improve performance while praise seems to backfire (Kahneman, 2002)). Mean reversion is ubiquitous in other economic time series, most notably in growth rates, and has been credited with being responsible for “[m]any great economic forecasting errors of the past half century [...]” (Pritchett and Summers, 2014).

We use data on under-five mortality rates for all developing countries that we obtain from the World Development Indicators 2014. Appendix A lists all 132 countries in our sample. We compute least squares-ARRs for all five year intervals between 1960–1964 and 2005–2009. The base model we estimate using the pooled sample is a regression of ARRs over five years on lagged

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<sup>4</sup>This has also been noted recently by McArthur (2014).

ARRs (i.e. over previous five-year episodes):

$$ARR_{it} = \beta_0 + \sum_{j=1}^L \beta_j ARR_{it-j} + \epsilon_{it}. \quad (3.1)$$

We use OLS to estimate (3.1) and thus refer to the resulting estimator as pooled ordinary least squares (POLS).

For simplicity, consider first the case in which  $L = 1$ , that is, (3.1) is just a regression of ARR<sub>it</sub> on ARR<sub>it-1</sub>. The coefficients of interest are both  $\beta_0$  and  $\beta_1$ : if  $\beta_0 = 0$  and  $\beta_1 = 1$ , the ARR observed over the last five years is an unbiased estimate of the ARR over the next five years. At the other extreme,  $\beta_1 = 0$  would suggest that current ARR<sub>it</sub> do not convey any information about future ARR<sub>it</sub> and that  $\beta_0$  is the best predictor available for future ARR<sub>it</sub>, the most extreme version of regression to the mean. Anything in-between would suggest that current ARR<sub>it</sub> are of some use for prediction and that there is some regression to the mean. If we observe regression to the mean, i.e.  $\hat{\beta}_1 < 1$ , the coefficient signals the rate at which the process reverts to its long-run mean, the estimate of which is  $\hat{\beta}_0 / (1 - \hat{\beta}_1)$ .

If we include additional lags, the sum over all coefficients  $\beta_1, \beta_2, \dots, \beta_L$  conveys information about the extent of mean reversion in ARR<sub>it</sub>.  $\sum_{j=1}^L \hat{\beta}_j < 1$  would suggest mean reversion and the long-run mean is  $\hat{\beta}_0 / (1 - \sum_{j=1}^L \hat{\beta}_j)$ . We will include up to three lags in the models we estimate.

We also consider more elaborate model specifications: first, we include on the right-hand side of (3.1) a linear time trend in order to account for the possibility of secular trends in ARR<sub>it</sub>, i.e. a trend in the long-run mean. We center this variable on 2010–2014 so that  $\hat{\beta}_0 / (1 - \sum_{j=1}^L \hat{\beta}_j)$  is the mean at that point in time. Second, we include the contemporaneous growth in GDP per capita.<sup>5</sup> Finally, we show in appendix B that the results presented in this section are fairly robust to estimation methods that account for unobserved heterogeneity across countries and contemporaneous correlation. While we find some evidence for the presence of unobserved, country-specific heterogeneity, using results from POLS will only tend to downplay the role of mean reversion

Results are reported in table 3 for all developing countries. Standard errors clustered at the country-level are reported in parentheses throughout. Consider first the simple model with one lag as the sole regressor reported in column (1). Note that the first observation on the outcome is for 1965–1969 as there is no observation on the lagged dependent for 1960–1964. The more lags we include, the smaller the time dimension of our sample.

The  $R$ -squared of this regression is one-third. Hence, there is evidence that past ARR<sub>it</sub> predict future ARR<sub>it</sub> to some extent. However, we also find evidence for mean reversion. The coefficient on the lagged ARR is significantly different from both zero and unity at the one-percent level. It suggests that ARR<sub>it</sub> revert to their long-run mean at a rate of about 0.6 every five years. The estimate for the long-run mean is an ARR of  $0.014 / (1 - 0.588) \approx 3.4$  percent. Note that

<sup>5</sup>The data come from the Penn World Tables Mark 8.0 (Feenstra et al., 2013). We use real GDP at constant 2005 national prices since we are not interested in cross-country comparison.

Table 3: Results from POLS regressions: testing for mean reversion in quinquennial ARR, all developing countries.

	1960–2005					1960–1995	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$ARR_{it-1}$	0.588*** (0.042)	0.717*** (0.067)	0.712*** (0.068)	0.746*** (0.082)	0.695*** (0.087)	0.657*** (0.085)	0.611*** (0.122)
$ARR_{it-2}$		-0.277*** (0.045)	-0.273*** (0.044)	-0.402*** (0.090)	-0.339*** (0.085)	-0.164*** (0.062)	-0.253* (0.150)
$ARR_{it-3}$				0.173*** (0.065)	0.119** (0.048)		0.146 (0.105)
$t$ (= 0 for 2010–2015)			0.001* (0.000)	0.001 (0.000)	0.001** (0.000)	-0.001 (0.000)	-0.001 (0.001)
$growth_{it}$					0.125*** (0.038)		0.117*** (0.037)
<i>Constant</i>	0.014*** (0.001)	0.019*** (0.002)	0.021*** (0.003)	0.019*** (0.002)	0.017*** (0.002)	0.013*** (0.003)	0.007** (0.004)
$\sum_{j=1}^L \hat{\beta}_j$	0.588	0.440	0.439	0.518	0.475	0.492	0.504
$\hat{\beta}_0 / (1 - \sum_{j=1}^L \hat{\beta}_j)$	0.035	0.034	0.038	0.039	0.033	0.025	0.014
Observations	1,020	888	888	756	633	624	413
Countries	132	132	132	132	110	132	103
R-squared	0.33	0.37	0.37	0.38	0.44	0.33	0.37

Standard errors clustered around the country-level in parentheses. \*, \*\*, and \*\*\* denote significance at the ten-, five-, and one-percent level, respectively.

this ARR is much lower than the 4.3 percent required to bring about a reduction in under-five mortality by two-thirds over the course of 25 years, the target under MDG4.

The model reported in column (2) includes one additional lag of the ARR which also turns out highly significant. The long-run mean is very similar to the one we report above. The model reported in column (3) includes a linear time trend and two lags of the dependent. Coefficients on lagged variables are very similar to those found before and remain significant. The coefficient on the trend variable is positive and significant, albeit only at the ten-percent level. It suggests that, on average, ARRs increase over time by about one-tenth of a percentage point every five years. The long-run mean in 2010–2014 is about 3.8 percent. Adding a third lag in column (4) shows that this may also have some predictive content but the change in the  $R$ -squared is only marginal. The coefficient on the trend variable is now insignificant.

The model reported in column (5) includes contemporaneous growth rates. All coefficient estimates are statistically significant at least at the five-percent level. Coefficients on lagged dependent variables remain fairly stable. The coefficient on the growth variable suggests that, *ceteris paribus*, a one percentage point higher growth rate increases the ARR by about one-eighth of a percentage point. The implied elasticity is somewhat lower than those reported in the literature. Pritchett and Summers (1996), for instance, find an elasticity of infant mortality rates with respect to GDP per capita of about  $-0.2$  to  $-0.4$  percent. Finally, in columns (6) and (7), we restrict the sample to observations that predate the MDG era, that is, we exclude

Table 4: Results from POLS regressions: testing for mean reversion in quinquennial ARRs, only countries in Sub-Saharan Africa.

	1960–2005				1960–1995		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$ARR_{it-1}$	0.548*** (0.069)	0.755*** (0.114)	0.742*** (0.115)	0.778*** (0.132)	0.680*** (0.139)	0.638*** (0.179)	0.567*** (0.156)
$ARR_{it-2}$		-0.492*** (0.059)	-0.471*** (0.057)	-0.555*** (0.081)	-0.546*** (0.081)	-0.413*** (0.096)	-0.654*** (0.186)
$ARR_{it-3}$				0.116 (0.072)	0.061 (0.087)		0.181 (0.180)
$t$ (= 0 for 2010–2015)			0.001* (0.001)	0.002** (0.001)	0.001* (0.001)	-0.001 (0.001)	-0.002* (0.001)
$growth_{it}$					0.147* (0.086)		0.156* (0.085)
<i>Constant</i>	0.011*** (0.001)	0.017*** (0.002)	0.022*** (0.004)	0.022*** (0.005)	0.018*** (0.005)	0.007 (0.005)	0.001 (0.006)
$\sum_{j=1}^L \hat{\beta}_j$	0.548	0.263	0.271	0.338	0.195	0.225	0.094
$\hat{\beta}_0 / (1 - \sum_{j=1}^L \hat{\beta}_j)$	0.025	0.022	0.030	0.033	0.023	0.009	0.001
Observations	370	325	325	280	266	235	182
Countries	45	45	45	45	42	45	42
R-squared	0.26	0.39	0.40	0.41	0.46	0.28	0.38

Standard errors clustered around the country-level in parentheses. \*, \*\*, and \*\*\* denote significance at the ten-, five-, and one-percent level, respectively.

all observations on ARRs recorded prior to 2000. We re-estimate models reported in columns (3) and (5) and find that the results are similar.

As an additional robustness check, we re-estimate all models with data only for the 45 Sub-Saharan Africa in our sample. Results are reported in table 4. As one would expect, we find that long-run means are somewhat lower. The sum over estimated coefficients on lagged dependent variables is lower, suggesting less mean reversion. Hence, our main finding of a strong tendency of ARRs to revert to the long-run mean remains intact.

What does mean reversion imply for the recent discussion surrounding under-five mortality and international development goals? First, recent calculations by [McArthur \(2014\)](#) that suggest that as many as seven million lives may have been saved through setting MDG4 may be flawed. The above results show that mean reversion is a robust characteristic of the data. Hence, relying on the assumption that trends observed during the 1990s would have been persistent absent any goals (or any other intervention) will trivially lead to this conclusion given the dismal performance of African countries during the 1990s. In other words, the improvement in the pace of mortality reduction in the 2000s in Africa is in part due to mean reversion and that part should arguably not be attributed to the MDGs. Second, assuming persistence in currently very high ARRs will result in overly optimistic projections for under-five mortality reductions in countries in Africa. This point will be analyzed in more detail in the section that follows.

## 4 Projections and development targets

### 4.1 Persistence vs. mean reversion

We base our projections on results of the mean reversion model reported in column (3) of table 3. For the first set of projections, we retain the relevant parameters from the regression and compute one-period-ahead-ARRs as

$$\widetilde{ARR}_{it+1}^{MR} = \widehat{\beta}_0 + \widehat{\beta}_1 ARR_{it} + \widehat{\beta}_2 ARR_{it-1} + \widehat{\gamma}(t+1). \quad (4.1)$$

By moving (4.1) forward through time, we obtain a series of ARR<sub>it</sub> that will converge to the long-run mean from which we can calculate the projected under-five mortality rate in 2030 and in 2035.

For comparison, we also calculate projected mortality rates in 2030 and 2035 based on the assumption that the last ARR<sub>it</sub> that we observe, those recorded between 2005 and 2009, will be persistent in each country individually:

$$\widetilde{ARR}_{it+1}^P = ARR_{it}.$$

Based on this, it is straight-forward to calculate projected levels of under-five mortality in 2030 and 2035. In principle, this is what is done by McArthur (2014) who extrapolates based on ARR<sub>it</sub> observed between 2001 and 2013.

Both projections will tend to result in conservative projections for Africa in the sense that they will tend to underestimate under-five mortality in the future. The persistence model, the model that assumes that current ARR<sub>it</sub> are also future ARR<sub>it</sub>, relies on ARR<sub>it</sub> observed between 2005 and 2009. These were higher for most African countries than in most other five-year periods for which data are available. McArthur (2014), for instance, uses twelve-year ARR<sub>it</sub> in order to “attenuate the risk that some countries might have seen unusually high rates of progress in the most recent years.”

The mean reversion model is also conservative for four reasons: first, we base our projections on a model that includes a linear time trend and our results suggest that, on average, ARR<sub>it</sub> increase over time. Second, the model we rely on for projections does not include country- or region-fixed effects. Therefore, ARR<sub>it</sub> will tend to converge to a global long-run mean (subject to a positive time trend) rather than country- or region-specific means. The global mean, in turn, was higher than that for Sub-Saharan Africa: the consecutive long-run means estimated from this model for 1960–1964, 1980–1984, 2000–2004, and, out-of sample, 2020–2024 are 0.027, 0.032, 0.036, and 0.040. Comparing these numbers to those reported in table 2, we see that Africa’s ARR was usually much lower and higher only between 2000 and 2009.<sup>6</sup> Third, the degree of persistence is higher than in models including country-fixed effects (see appendix B). Finally,

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<sup>6</sup>Our estimates of fixed effects obtained from the model reported in column (9) of table 3 differ substantially by region: the mean fixed effect is above 0.030 for all regions except Sub-Saharan Africa where it is only 0.019.

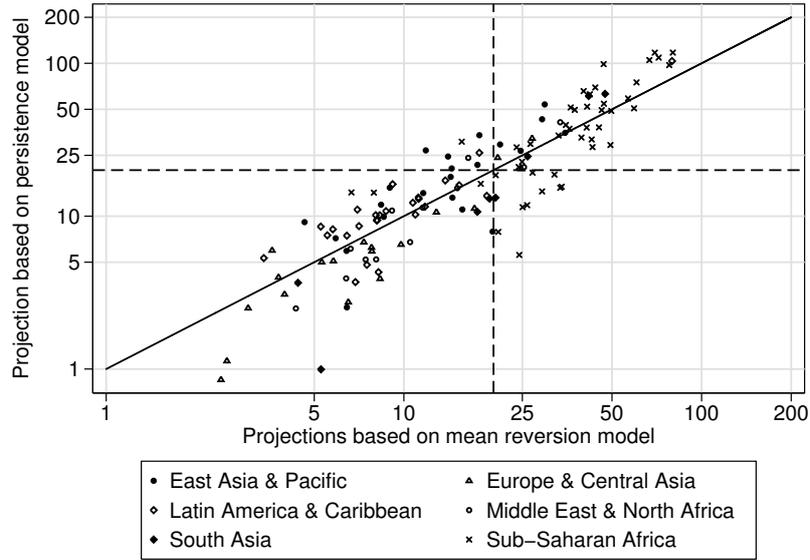


Figure 3: Projections of under-five mortality based on persistence model against projections based on mean reversion model. The dashed lines indicate the new development goal, an under-five mortality rate of 20 per 1,000. The solid line is a 45-degree-line. Both series are plotted on a log scale. Own calculations based on data from the World Development Indicators 2014.

the model we use does not allow for the pattern of relative divergence that we find for previous decades (see section 2).

The results of these alternative projections for the year 2030 are depicted in figure 3 where we plot projections from the persistence model against projections from the mean reversion model. Both projections are plotted on log scales. The dashed lines represent the new target, a mortality rate of 20 per 1,000. We also add a 45-degree-line to this graph for reference.

All countries located in the bottom-right corner of the graph will attain the goal if current ARRs turn out to be persistent but will not attain the goal if they experience regression to the mean. On the other hand, countries located in the top-left corner of the graph will not attain the goal under persistence but will attain the goal if there is regression to the mean.

The first thing to note is that there is a strong linear relationship between the two sets of projections. The correlation coefficient between logs of projected rates is 0.90 and is highly significant ( $p$ -value  $< 0.0001$ ). Based on an unpaired  $t$ -test (allowing for unequal variances), we cannot reject the null of equal means ( $p$ -value = 0.80). Results are similar for projections until 2035 ( $p$ -value = 0.85). There is no tendency for either approach to result in higher or lower projected mortality rates *on average*.

The geographical distribution of mortality rates, however, differs considerably. Several countries in the bottom-right corner of the graph, mostly located in Africa, are projected to attain the target if current ARRs are also future ARRs but will fail to do so under regression to the

mean. On the other hand, countries in the top-left corner, those that will attain the target if they experience regression to the mean but not if their current ARR's persist, are mostly located in East Asia and the Pacific region.

Table 5 allows a closer inspection of these regional differences. We tabulate the total number of countries by region, the number of countries that had attained a level of at most 20 per 1,000 already in 2013, and the number of countries that attain the new goal with and without taking into account mean reversion in 2030 and 2035, respectively. Note that more than one-third of all developing countries in our sample had attained the target in 2013—*even before it was agreed on*. The share of countries is particularly high in developing countries in Europe and Central Asia, where only five countries have had under-five mortality rates of more than 20 per 1,000. In Latin America and the Caribbean, more than three out of five countries had attained the target already. The share is particularly low in Africa, where only two out of 45 countries had attained the target by 2013. Thus, the new target would be of little relevance to a large number of countries outside Africa yet relevant to almost all African countries.

The two sets of projections result in a very similar number of developing countries that will attain the target by 2030 in Europe and Central Asia, in Latin America and the Caribbean, in the Middle East and North Africa, and in South Asia. Large differences between projections are also observed for East Asia and the Pacific and for Africa. Under the persistence scenario, only five out of 15 countries in East Asia and the Pacific are projected to attain the target while ten are projected to do so under mean reversion.<sup>7</sup>

In Africa, nine out of 43 countries are projected to attain the target under persistence. This would mean that three out of five countries that will have under-five mortality rates in excess of 20 per 1,000 in 2030 are African. Under the mean reversion scenario, only two out of 43 countries are projected to attain the target. This scenario would see close to four-fifths of the future ‘SDG failures’ hailing from Africa.

Could high rates of economic growth put the target within reach for more countries in Africa? In order to quantify the potential contribution of growth and to test the sensitivity of our projections above, we calculate a set of alternative projections based on estimates reported in column (5) of table 3 for which we rely on varying assumptions about future growth rates of GDP per capita. Results are reported in appendix C. They suggest that if all countries in Africa manage to maintain a growth rate of five percent per year, still only five percent of the countries in this region for which the target is relevant will have attained it come 2030. This percentage increases to 23 percent for a very high growth rate of ten percent annually. All but eight non-African countries that have not trivially attained the target would cross the line given this rapid pace of economic development. Remember that these projections are conservative

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<sup>7</sup>Note that the East Asia and Pacific region is characterized by a large percentage of countries that have already attained under-five mortality rates of less than 20 per 1,000—7 out of 22—and much variation in ARR's and initial levels recently. See appendix A. Countries that are projected to attain an under-five mortality rate of no more than 20 per 1,000 under the mean reversion model but not under the persistence model are Fiji, Micronesia, the Marshall Islands, the Philippines, and the Solomon Islands. However, all these countries are projected to come reasonably close.

Table 5: Number of countries by region that are projected to attain an under-five mortality rate of less than 20 per 1,000 by 2030.

	Projections													
	2030						2035							
	$\leq 20$ in 2013		without mean reversion		with mean reversion		without mean reversion		with mean reversion		without mean reversion			
#	Share	#	Share	#	Share	#	Share	#	Share	#	Share	#	Share	
East Asia & Pacific	22	0.32	5	0.33	10	0.67	7	0.47	12	0.80	7	0.47	12	0.80
Europe & Central Asia	19	0.74	2	0.40	2	0.40	3	0.60	4	0.80	3	0.60	4	0.80
Latin America & Caribbean	26	0.62	8	0.80	9	0.90	8	0.80	9	0.90	8	0.80	9	0.90
Middle East & North Africa	12	0.50	3	0.50	4	0.67	4	0.67	4	0.67	4	0.67	4	0.67
South Asia	8	0.25	3	0.50	2	0.33	3	0.50	3	0.50	3	0.50	3	0.50
Sub-Saharan Africa	45	0.04	9	0.21	2	0.05	13	0.30	7	0.16	13	0.30	7	0.16
All	132	0.36	30	0.35	29	0.34	38	0.45	39	0.46	38	0.45	39	0.46

Projections without mean reversion are based on the assumption of persistence in ARRs observed between 2005 and 2010. Mean reversion-projections are based on estimates reported in column (3) of table 3. Own calculations based on data from the World Development Indicators 2014.

in the sense that they will tend to overestimate future ARR<sub>s</sub> and thus underestimate future mortality rates. Models that account for country-specific long-run ARR<sub>s</sub> result in a greater degree of mean reversion and lower long-run ARR<sub>s</sub> for African countries (see the discussion and results in appendix B).

We can also ask whether the general picture would change significantly if one allows for an additional five years to attain the target. Results are reported in the final four columns of table 5. Projections based on the mean reversion model are slightly more optimistic in this case: overall, 39 countries are projected to cross the line as opposed to just 29 countries in the mean reversion scenario. At least half of the countries in each individual region that had not attained the target in 2013 already are projected to cross the line. The only exception is Africa where only 16 percent—seven countries—will have done so.

Three messages should be taken away from this: first, irrespective of the underlying assumptions, Africa is always the one region in which the smallest share of countries stands a chance at success. Second, mean reversion matters. If only a weak form of it will materialize in the future, the absolute number of countries that will be SDG success stories from Africa will be extremely limited. Third, there is a substantial number of developing countries that has attained the target even before it was sanctioned, but only two of them are in Africa. The proposed new target seems both unfair to Africa and *irrelevant* for many countries elsewhere.

What is maybe even more questionable is that just at a time when a uniform target defined in terms of a common relative reduction seems more viable, actors opt for a target that reproduces biases in the previous child mortality goal that have been noted and criticized before (Clemens et al., 2007; Easterly, 2009; Klasen and Lange, 2012). In what follows, we will further explore this last point by analyzing how our projections compare to a ‘re-newed’ MDG4.

## 4.2 Old MDG = new SDG

How would our assessment of Africa’s prospects change if the new under-five mortality target would be the old target? We have argued above that in 2000, setting 1990 as the base year and calling for a reduction by two-thirds was overly ambitious for most countries in Africa. This time could be different as (1) there is a tendency for ARR<sub>s</sub> to increase over time, (2) countries in Africa have an advantage in that they have seen high ARR<sub>s</sub> over the last ten years, and (3) given a degree of persistence in the data, this momentum will carry over to some extent to future ARR<sub>s</sub>. Given mean reversion, one advantage of a new target defined in relative terms would be that the focus shifts from countries with high levels of under-five mortality to countries with low ARR<sub>s</sub> in recent years. Re-newing the old target would also have the obvious advantage that it would be immediately relevant for all countries.

Replicating the old MDG would see 2005 as the base year and calling for a reduction by two-thirds until 2030. The target mortality rate is thus

$$M_i^{MDG} = (1/3)M_{i,2005}.$$

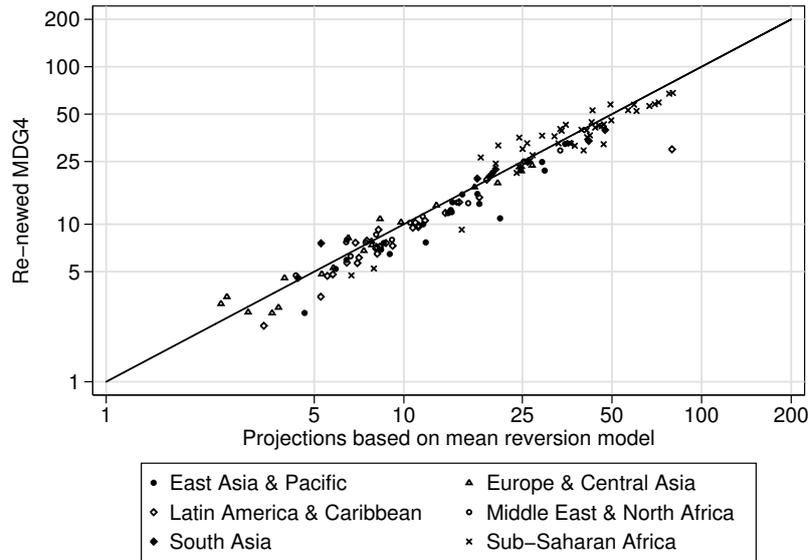


Figure 4: Under-five mortality rates as required by a ‘re-newed’ MDG4 (two-thirds reduction relative to levels in 2005) against projections based on mean reversion-model. Both series are plotted on a log scale. Own calculations based on data from the World Development Indicators 2014.

Figure 4 compares our projections from above (i.e. based on estimates reported in column (3) of table 3) to this quantity. Both series are plotted on log scales. Countries above the 45-degree-line are projected to attain the target while countries below the line are projected to have lower mortality rates in 2030 than would be required under a new MDG4.

Table 6 reports the exact numbers of countries that are projected to attain the target by region. Fewer than one-third of all developing countries in our sample are projected to attain the target. This suggests that a re-newed MDG4 would still be ambitious today. In comparison to the total, the success rate is higher in Europe and Central Asia, in the Middle East and North Africa, in South Asia, and also in Sub-Saharan Africa. The reason for this is that countries in Africa have seen high ARRs between 2005 and 2009 and this momentum is going to carry over to some extent into the future.

Taken together, this suggests that a re-newed MDG may be ambitious yet in reach for most countries. It would be more demanding of countries that have seen below-average progress in recent years so that the focus would shift away from levels towards recent progress. Of course, projections presented in this section are premised on the assumption that there will be no return to the pattern of relative divergence discussed in section 2 which we argued is still very much possible.

Table 6: Number of countries projected to attain a ‘re-newed’ MDG4 by 2030 by region.

	# of countries	Attaining new MDG4	
		#	Share
East Asia & Pacific	22	2	0.09
Europe & Central Asia	19	8	0.42
Latin America & Caribbean	26	4	0.15
Middle East & North Africa	12	4	0.33
South Asia	8	5	0.62
Sub-Saharan Africa	45	16	0.36
All	132	39	0.30

Projections are based on estimates reported in column (3) in table 3. Own calculations based on data from the World Development Indicators 2014.

## 5 Future challenges

The previous sections have shown that (1) there is substantial evidence for regression to the mean and (2) that accounting for this results in projections that suggest a very different regional distribution of achievements with respect to the new child mortality goal. There are other reasons to expect ARRs to slow down over the coming 15 years which we will discuss in what follows.

### 5.1 Sustaining economic growth

Africa’s growth in output is widely believed to have exceeded five percent per year since the mid-1990s. This would make the region second only to emerging and developing Asia in terms of recent economic development (IMF, 2014, p. 184). We have seen above that economic growth is robustly associated with higher ARRs, although our estimate of the elasticity is not particularly high. We have nevertheless argued that sustained growth would significantly improve Africa’s prospects with respect to the new child mortality goal (see appendix C). It is thus worthwhile to ask whether growth will continue its role in facilitating progress. We argue that it is unlikely that this will be the case.

One point about Africa’s recent growth performance is that we cannot be all too certain about it as the continent’s growth data are inherently unreliable (Jerven, 2010). There have been alternative takes at growth in Africa, notably by Young (2012). He bases his measurement of real consumption on easy-to-observe indicators such as the quality of housing and the ownership of durable assets and estimates that living standards have been growing at a rate between three and four percent per year. However, it has been questioned whether this approach is valid (Harttgen et al., 2013).

But let us assume for now that Africa’s growth performance has rivaled East Asia’s for the last ten to 15 years. Will it be possible to maintain these rates of growth? One point that casts doubt on this prospect is the absence of any signs of structural change in Africa in recent

Table 7: Levels and changes in health service utilization and health behavior in Sub-Saharan Africa, 2000 and 2010.

	2000	2010	Difference
<i>Vaccinations</i>			
DPT (% of children ages 12–23 months)	51.63	72.01	20.37
BCG (% of one-year-old children)	68.10	82.21	14.11
Measles (% of children ages 12–23 months)	52.69	73.55	20.87
<i>Infrastructure</i>			
Improved water source (% of population with access)	55.03	62.61	7.58
Improved sanitation facilities (% of population with access)	25.92	29.08	3.16
<i>Service use</i>			
ARI treatment (% of children under five taken to health provider)	40.51	51.79	11.28
Births attended by skilled health staff (% of total)	42.08	49.72	7.64

Own calculations based on data from the World Development Indicators 2014.

years towards manufacturing (McMillan and Rodrik, 2011). While Africa’s labor force has been shifting out of agriculture (McMillan and Harttgen, 2014), they have not found employment in industries associated with high productivity growth. Instead, they relocated to market services. While these had above-average productivity levels at the time, they are also associated with low productivity growth (de Vries et al., 2013).

An additional point to keep in mind is that growth in Africa depends on growth elsewhere. Easterly (2001), for instance, speculates that the growth slowdown observed in developing countries during the 1980s and 1990s is largely due to a concurrent slowdown in the developed world. Growth rates in Africa today depend also on growth in East Asia, particularly growth in China, and recent studies have suggested that this region may see a deceleration in the near future (Pritchett and Summers, 2014).<sup>8</sup>

## 5.2 What health policies for future progress?

An important question in the context of our investigation of the usefulness of the newly proposed under-five mortality-goal is from which kind of policies and interventions future reductions in under-five mortality are going to stem from. We argue that (1) much of the low-hanging fruits may have been reaped, that (2) future progress is going to depend on an increased focus on health interventions that require greater state *capacity* (or strength) as opposed to *scope*, and that (3) such activities have historically been found to be harder to bring about in terms of the time required to implement them.

<sup>8</sup>The reason cited for this is the same as the one that we cited for a slowdown in ARRs—growth rates show an even higher degree of mean reversion.

Table 7 tabulates levels and changes in selected health indicators between 2000 and 2010 for which aggregate data for Sub-Saharan Africa were available from the World Development Indicators. We classify indicators according to whether they are related to vaccination campaigns, infrastructure investment, or health service use and report figures in this order from top to bottom. What matters for future progress in terms of avoiding premature child deaths is arguably the change in the percentage of the population covered. Therefore, current rates of coverage are an indicator of the potential of these interventions to bring about reductions in under-five mortality in the future.<sup>9</sup> Table 7 shows that vaccination coverage in Africa is now at comparatively high levels. Future progress may have to stem primarily from interventions aimed at improving infrastructure (e.g. access to safe drinking water) and up-take of health-related services (e.g. births delivered through skilled health staff), which are still at lower levels.

What is required to bring about improvements in these fields? Health interventions differ in terms of what kind of institutional environment has to be in place in order for them to be effective. Some interventions require resources but little government capacity. One-shot vaccines and the distribution of bed nets against malaria which do not require highly-skilled health personnel are prime examples (Fukuyama, 2004). From table 7 we see that much progress has been made in vaccination coverage recently. There is also some evidence that the distribution of insecticide-treated bed nets (ITBs) accounts for large portions of the decline in infant mortality rates in some places. Demombynes and Trommlerová (2012) attribute half of the decline in this indicator to the use of ITBs which increased from eight to 60 percent between 2003 and 2008. Overall, it is plausible that high rates of economic growth in combination with readily-available, low-cost, and low-tech interventions account for much of the recent decline in under-five mortality rates in Sub-Saharan Africa.

Other treatments require substantially higher government capacity. Anti-retroviral drugs, for instance, must be taken in complex doses over lengthy time periods. Effectiveness thus requires a strong public-health infrastructure (Fukuyama, 2004). Another example are small-scale infrastructure projects to improve water quality at the point-of-use. These interventions are generally effective in preventing diarrhea in children under five (Clasen et al., 2007) which, in turn, is the second leading cause of death in children under five (WHO, 2014). The lack of safe drinking water also contributes to the spread of water-borne diseases. However, the sole construction of wells, a prime activity of governments and external development agencies in recent years, is only the first step. Wells require frequent maintenance and sometimes repair which, in turn, requires some technical know-how and the capability to provide such public goods. Surveys of the functionality of wells in Africa and other developing regions frequently find that a large number is in need of repair. For instance, Miguel and Gugerty (2005) use data on wells constructed with the assistance of the Finnish government in Western Kenya. As is common in such projects, foreign assistance was limited to the construction of the wells and provision of the equipment required for operation while actual maintenance was the responsibility of local

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<sup>9</sup>We simplify to some extent. Even with full coverage there may be technological advances such as more effective vaccines and longer-lasting bed nets that may bring about further gains.

well committees. Despite the importance of access to safe drinking water, they report that only 57 percent of these wells were fully functional in 2000/2001, suggesting wide-spread failures of local collective action in well maintenance. Such projects are therefore a prime example of interventions that require some capacity in order to be sustainable.

Government capacity is also key to a functioning health care system, in turn a prerequisite for high levels of up-take. Table 7 tabulates levels and changes in the proportion of children with acute respiratory infections (ARIs) taken to a health provider and the proportion of births attended by skilled personnel. These figures suggest that there is still some room for improvements in the future through changes in health-seeking behavior. The quality of health services in many developing countries is, however, poor. Based on data on medical care quality from four developing countries Das et al. (2008) find that not only is the competence of doctors in these countries low. Doctors also exert less effort and thus do not bring to bear what little knowledge they have. In Tanzania, for instance, doctors complete only 24 percent of the essential checklist when faced with a patient with malaria and only 38 percent when the patient is a child with diarrhea (Leonard and Masatu, 2007). Similarly, Reyburn et al. (2004) find less than half of all patients treated for malaria in hospitals in northeast Tanzania were actually suffering from malaria. As long as these quality-issues persist, the effectiveness of improving treatments is severely limited. Solving this kind of incentive problem requires institutional change, a challenge that while surmountable, is arguably more difficult to bring about (World Bank, 2004).

## 6 Conclusion and interpretations

Compared to earlier efforts of international goal-setting, one of the major innovations of the MDG process has been the introduction of numerical targets, some of which are measurable and time-limited. This has been tainted somewhat by the insight that attaining most targets, including MDG4, was all but impossible for the poorest countries. If international goal-setting for the developing community is to remain a successful venture, both with respect to galvanizing support and bringing about policy changes, future goals should not only be ambitious and easy to communicate, they should also be realistic.

Just as targets for under-five mortality defined in relative terms are starting to look more reasonable than in the past, recent proposals have called for a recasting of MDG4 as a level-end goal, an absolute minimum standard that most commentators put at about 20 deaths per 1,000 by 2030. This paper shows that these recent proposals are overly ambitious for countries in Africa and that empirical studies that demonstrate their alleged feasibility by extrapolating from recent rates are likely misleading. At the same time, the prospective target is not relevant for all countries as many developing countries have already attained it.

It may thus be that the new goal-setters got carried away by recent progress and are now running the danger of committing the same mistake as with the MDGs: setting unrealistic mortality targets for Africa.

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## A List of countries in the analysis

We list here all 132 developing countries in our analysis along with the ARR (in percent) observed between 2005 and 2010 and the under-five mortality rate in 2013 (printed bold whenever it is no more than 20 per 1,000 in that year). All data come from the World Development Indicators 2014.

*East Asia & Pacific:* Cambodia (7.9, 38); China (8.4, **13**); Fiji (-0.6, 24); Indonesia (4.4, 29); Kiribati (0.7, 58); Korea, Dem. Rep. (0.3, 27); Lao PDR (3.9, 71); Malaysia (-0.4, **9**); Marshall Islands (0.7, 38); Micronesia, Fed. Sts. (3.0, 36); Mongolia (5.5, 32); Myanmar (3.6, 51); Palau (3.2, **18**); Papua New Guinea (2.1, 61); Philippines (2.2, 30); Samoa (0.9, **18**); Solomon Islands (1.4, 30); Thailand (4.3, **13**); Tonga (3.0, **12**); Tuvalu (2.8, 29); Vanuatu (2.2, **17**); Vietnam (2.9, 24).

*Europe & Central Asia:* Albania (4.3, **15**); Armenia (5.1, **16**); Azerbaijan (5.8, 34); Belarus (9.0, **5**); Bosnia and Herzegovina (1.1, **7**); Bulgaria (4.5, **12**); Georgia (8.2, **13**); Hungary (4.6, **6**); Kazakhstan (7.9, **16**); Kyrgyz Republic (5.0, 24); Macedonia, FYR (5.5, **7**); Moldova (5.1, **15**); Montenegro (8.2, **5**); Serbia (3.1, **7**); Tajikistan (4.5, 48); Turkey (5.9, **19**); Turkmenistan (3.1, 55); Ukraine (4.1, **10**); Uzbekistan (3.2, 43).

*Latin America & Caribbean:* Argentina (3.2, **13**); Belize (3.2, **17**); Bolivia (5.6, 39); Brazil (6.9, **14**); Colombia (2.9, **17**); Costa Rica (0.8, **10**); Cuba (1.2, **6**); Dominica (2.5, **11**); Dominican Republic (2.8, 28); Ecuador (3.0, 23); El Salvador (6.1, **16**); Grenada (2.2, **12**); Guatemala (3.7, 31); Guyana (2.1, 37); Haiti (2.5, 73); Honduras (4.3, 22); Jamaica (2.9, **17**); Mexico (2.8, **14**); Nicaragua (3.9, 23); Panama (2.9, **18**); Paraguay (3.3, 22); Peru (7.0, **17**); St. Lucia (1.7, **14**); St. Vincent and the Grenadines (1.2, **19**); Suriname (3.2, 23); Venezuela, RB (3.0, **15**).

*Middle East & North Africa:* Algeria (4.2, 25); Djibouti (3.0, 70); Egypt, Arab Rep. (5.9, 22); Iran, Islamic Rep. (6.1, **17**); Iraq (2.1, 34); Jordan (3.1, **19**); Lebanon (6.7, **9**); Libya (6.8, **14**); Morocco (3.9, 30); Syrian Arab Republic (4.3, **15**); Tunisia (5.7, **15**); Yemen, Rep. (4.9, 51).

*South Asia:* Afghanistan (2.5, 97); Bangladesh (6.2, 41); Bhutan (6.5, 36); India (4.3, 53); Maldives (11.4, **10**); Nepal (5.9, 40); Pakistan (2.0, 86); Sri Lanka (5.1, **10**).

*Sub-Saharan Africa:* Angola (2.2, 167); Benin (4.4, 85); Botswana (3.0, 47); Burkina Faso (6.5, 98); Burundi (5.0, 83); Cabo Verde (-0.5, 26); Cameroon (3.6, 94); Central African Republic (1.8, 139); Chad (1.9, 147); Comoros (2.5, 78); Congo, Rep. (9.2, 49); Cote d'Ivoire (3.4, 100); Eritrea (4.6, 50); Ethiopia (7.6, 64); Gabon (3.7, 56); Gambia, The (3.8, 74); Ghana (1.2, 78); Guinea (4.0, 101); Guinea-Bissau (2.9, 124); Kenya (4.1, 71); Lesotho (2.2, 98); Liberia (7.7, 71); Madagascar (5.6, 56); Malawi (7.8, 68); Mali (4.7, 123); Mauritania (2.2, 90); Mauritius (0.3, **14**); Mozambique (5.5, 87); Namibia (5.2, 50); Niger (6.7, 104); Nigeria (3.8, 117); Rwanda (10.8, 52); Sao Tome and Principe (4.4, 51); Senegal (7.9, 55); Seychelles (0.0, **14**); Sierra Leone (2.9, 161); Somalia (1.5, 146); South Africa (5.6, 44); Sudan (2.5, 77); Swaziland (4.2, 80); Tanzania (7.7, 52); Togo (2.8, 85); Uganda (6.7, 66); Zambia (4.7, 87); Zimbabwe (-0.1, 89).

## B Results from dynamic panel data (DPD) estimators

Table 8 presents results from more sophisticated DPD estimation methods. The models we estimate include two lags of the dependent as regressors and, in one specification, the contemporaneous growth rate of GDP per capita. The reason for this choice is that we find no evidence for serial correlation in the error terms for these specifications, indicating that the dynamics of these models are not misspecified.

Table 8: Results from DPD estimators: testing for mean reversion in quinquennial ARRs, all developing countries.

	(1)	(2)	(3)	(4)	(5)	(6)
	POLS	FE	Diff-GMM	POLS	FE	Diff-GMM
$ARR_{it-1}$	0.712*** (0.067)	0.553*** (0.078)	0.613*** (0.110)	0.700*** (0.069)	0.534*** (0.079)	0.643*** (0.108)
$ARR_{it-2}$	-0.242*** (0.042)	-0.381*** (0.054)	-0.377*** (0.083)	-0.226*** (0.049)	-0.359*** (0.060)	-0.305*** (0.069)
$growth_{it}$				0.098*** (0.033)	0.112*** (0.039)	0.076* (0.042)
$\sum_{j=1}^L \hat{\beta}_j$	0.471	0.173	0.236	0.474	0.175	0.338
Observations	888	888	756	736	736	626
Countries	132	132	132	110	110	110
R-squared	0.41	0.52		0.47	0.57	
<i>Hansen-test for exogeneity of instruments:</i>						
Exogen. instruments			10			11
<i>p</i> -value of Hansen test			0.29			0.75
<i>p-values of Arellano-Bond-test for serial correlation:</i>						
$AR(1)$	0.571	0.359	0.000	0.866	0.115	0.000
$AR(2)$	0.325	0.191	0.365	0.700	0.316	0.798
$AR(3)$	0.771	0.000	0.279	0.871	0.000	0.490
$AR(4)$	0.935	0.000	0.185	0.994	0.000	0.220

Standard errors clustered around the country-level in parentheses. \*, \*\*, and \*\*\* denote significance at the ten-, five-, and one-percent level, respectively. All models include a complete set of time-fixed effects.

As a first robustness check, we replace linear trends with time-fixed effects. This accounts for contemporaneous correlation, often the most important form of cross-unit correlation in these applications. Results from estimating these specifications via POLS are presented in columns (1) and (4) of table 8, respectively. Coefficient estimates on lagged terms are very similar to those we saw in section 3 (e.g. coefficients reported in column (3) of table 3). *p*-values of the Arellano-Bond-test (Arellano and Bond, 1991) suggest that there is no evidence for serial correlation of orders one through four.

One additional concern may be unobserved heterogeneity across countries. If the error term in (3.1) includes a country-specific component, POLS will usually result in upward-biased coefficient estimates as both the dependent and its lags will be positively correlated with the composite error (Nickell, 1981). Note, however, that upward-biased estimates are conservative in our application as they would suggest less mean reversion in the data. The standard approach to deal with unobserved, time-invariant heterogeneity when panel data is available is to include country-fixed effects. However, this is usually no recipe against dynamic panel bias (Nickell, 1981; Bond, 2002). Including fixed effects is equivalent to running OLS on the de-meaned data and, by construction, the de-meaned error term will be negatively correlated with the de-meaned lagged dependent variables. The bias will be decreasing in  $T$  but since  $T$  is quite short in our case, we may expect the bias in fixed effects (FE)-estimates to be significant. Roodman (2009b) argues that reporting results from FE estimation is nevertheless useful as coefficient estimates on the lagged dependent

from POLS and FE models usually provide a plausible range for the actual coefficient of interest. The same applies for the sum over coefficient estimates, an indicator of the extent of mean reversion. We report results from FE models in columns (2) and (5) and find that the estimate on the once-lagged dependent is indeed lower and so is the sum over coefficients. The plausible ranges implied by the POLS and FE estimates is narrow—0.173–0.471 and 0.175–0.474. Note, however, that there is evidence for higher-order serial correlation, suggesting that FE models suffer from specification problems.

Finally, we employ GMM estimators in order to obtain consistent estimates of the dynamics of ARRs. We use [Arellano and Bond’s \(1991\)](#) Difference-GMM estimator that relies on first-differencing for purging fixed effects and instrumenting the differenced lagged dependent with lagged levels.<sup>10</sup> It is often important to keep the instrument count low as too many instruments relative to observations will tend to result in finite sample-bias ([Roodman, 2009a](#)). Therefore, we use as instruments only the ‘collapsed’ set (i.e. we do not employ separate instruments for each time period) and only the second, third, and fourth lag of the dependent variable. This results in ten and eleven instruments, respectively.

Results are reported in columns (3) and (6). As one would expect, the sum over both coefficient estimates on the lagged dependent variables falls between those for POLS and FE results. However, they are closer to FE results suggesting that we over-estimate the extent the persistence in ARRs in our projections in section 4. There is no evidence for serial correlation (except of order one which is to be expected after differencing) and a Hansen-test of overidentifying restrictions suggests that we cannot reject exogeneity of instruments.

Overall, our results in this appendix indicate that while there is some evidence for the presence of a country-specific, time-invariant component in the error term, the resulting bias in POLS estimates still seems to be moderate. Note that using consistent estimates for projections is not an option as fixed effects are purged rather than estimated. It is important to remember that upward biased coefficient estimates and the omission of country-specific long-run means from the model only render our projections conservative in the sense that we will tend to under-estimate under-five mortality rates in Africa in the future.

## C Alternative projections

We derive a set of additional projections that are based on regression results reported in column (5) in table 3, i.e. the model that includes the first, second, and third lag of the dependent variable, a linear time trend, and the average rate of growth of GDP per capita over five years. We make alternative assumptions about future growth rates of GDP per capita, 3.5, 5, 6.8, and 8 percent, respectively, and calculate the share of countries in each region that would achieve an under-five mortality rate of 20 or less in 2030. Results are reported in table 9. Note that the

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<sup>10</sup>A popular alternative is System-GMM ([Arellano and Bover, 1995](#); [Blundell and Bond, 1998](#)) but this requires that differences are orthogonal to the fixed effects. Since African countries have had both lower ARRs and have seen a large acceleration in ARRs recently, this assumption is unlikely to hold. See [Roodman \(2009a\)](#) for details.

number of countries in the second column refers to the number of countries that had not already achieved an under-five mortality rates of no more than 20 per 1,000.

Table 9: Percentage of countries projected to achieve an under-five mortality rate of no more than 20 per 1,000 by 2030 under alternative assumptions about economic growth.

	#	Growth rates (percent)				
		3.5	5.0	6.5	8.0	10.0
East Asia & Pacific	15	0.73	0.73	0.73	0.73	0.80
Europe & Central Asia	5	0.40	0.60	0.60	0.80	0.80
Latin America & Caribbean	10	0.90	0.90	0.90	0.90	0.90
Middle East & North Africa	6	0.67	0.67	0.67	0.67	0.83
South Asia	6	0.50	0.50	0.50	0.50	0.67
Sub-Saharan Africa	43	0.02	0.05	0.09	0.14	0.23

Projections are based on estimates reported in column (5) in table 3. Own calculations based on data from the World Development Indicators 2014.

Results indicate that even under very favorable economic circumstances until 2030, the target would be biased against countries in Africa. Even if all countries in the region managed to bring about a growth rate of ten percent per year, a scenario that seems extremely unlikely (see section 5.1), less than two out of five countries in Africa would attain an under-five mortality rate of no more than 20 per 1,000 deaths. The success rate is projected to be less than one-fourth if countries in Africa managed to grow at a rate of 6.5 percent per year, one percentage point higher than the growth rate recorded between 1996 and 2005 (IMF, 2014, p. 184).