Status and drivers of maternal, newborn, child and adolescent health in the Islamic world: a comparative analysis

Nadia Akseer, Mahdis Kamali, Nour Bakhache, Maaz Mirza, Seema Mehta, Sara Al-Gashm, Zulfiqar A Bhutta

Summary

Background The Millennium Development Goal (MDG) period saw dramatic gains in health goals MDG 4 and MDG 5 for improving child and maternal health. However, many Muslim countries in the south Asian, Middle Eastern, and African regions lagged behind. In this study, we aimed to evaluate the status of, progress in, and key determinants of reproductive, maternal, newborn, child, and adolescent health in Muslim majority countries (MMCs). The specific objectives were to understand the current status and progress in reproductive, maternal, newborn, child, and adolescent health in MMCs, and the determinants of child survival among the least developed countries among the MMCs; to explore differences in outcomes and the key contextual determinants of health between MMCs and non-MMCs; and to understand the health service coverage and contextual determinants that differ between best and poor or moderate performing MMCs.

Methods In this country-level ecological study, we examined data from between 1990 and 2015 from multiple publicly available data repositories. We examined 47 MMCs, of which 26 were among the 75 high-burden Countdown to 2015 countries. These 26 MMCs were compared with 48 non-Muslim Countdown countries. We also examined characteristics of the eight best performing MMCs that had accelerated improvement in child survival (ie, that reached their MDG 4 targets). We estimated adolescent, maternal, under-5, and newborn mortality, and stillbirths, and the causes of death, essential interventions coverage, and contextual determinants for all MMCs and comparative groups using standardised methods. We also did a hierarchical multivariable analysis of determinants of under-5 mortality and newborn mortality in low-income and middle-income MMCs.

Findings Despite notable reductions between 1990 and 2015, MMCs compared with a global esimate of all countries including MMCs had higher mortality rates, and MMCs relative to non-MMCs within Countdown countries also performed worse. Coverage of essential interventions across the continuum of care was on average lower among MMCs, especially for indicators of reproductive health, prenatal care, delivery, and labour, and childhood vaccines. Outcomes within MMCs for mortality and many reproductive, maternal, newborn, child, and adolescent health indicators varied considerably. Structural and contextual factors, especially state governance, conflict, and women and girl's empowerment indicators, were significantly worse in MMCs compared with non-MMCs within the high-burden Countdown countries, and were shown to be strongly associated with child and newborn mortality within low-income and middle-income MMCs. In adjusted hierarchical models, among other factors, under-5 mortality in MMCs increased with more refugees originating from a country (β=23·67, p=0·0116), and decreased with better political stability or absence of terrorism (β=–0·99, p=0·0285), greater political rights or government effectiveness (β=–1·17, p<0·0001), improvements in log gross national income per capita (β=–4·44, p<0·0001), higher total adult literacy (β=–1·69, p<0·0001), higher female adult literacy (β=–0·97, p<0·0001), and greater female to male enrolment in secondary school (β=–16·1, p<0·0001). The best performing MMCs were Azerbaijan, Bangladesh, Egypt, Indonesia, Kyrgyzstan, Morocco, Niger, and Senegal, which had higher coverage of family planning interventions and newborn or child vaccinations, and excelled in many of the above contextual determinants when compared with moderate or poorly performing MMCs.

Interpretation The status and progress in reproductive, maternal, newborn, child, and adolescent health is heterogeneous among MMCs, with little indication that religion and its practice affects outcomes systemically. Some Islamic countries such as Niger and Bangladesh have made great progress, despite poverty. Key findings from this study have policy and programmatic implications that could be prioritised by national heads of state and policy makers, development partners, funders, and the Organization of the Islamic Cooperation to scale up and improve these health outcomes in Muslim countries in the post-2015 era.

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Introduction

The world has made major strides in improving maternal and child health and mortality across the Millennium Development Goals (MDG) period spanning 1990–2015.[1,2] Launched in the year 2000, the Millennium Declaration set targets for improving health and reducing mortality of children by two-thirds (MDG 4) and mothers by three-quarters (MDG 5) from 1990 base figures.[1,2] Globally,

Research in context

Evidence before this study

We searched MEDLINE, Embase, Global Health Library (IMEMR), and Scopus electronic databases for articles published from Jan 1, 1980, to Dec 6, 2016, concerning the health of Muslim populations or countries without language restrictions. Studies that did not include at least one Muslim-majority country, were of men only, or were published before 1980 were excluded. Broad search terms used include (muslim* OR islam* OR moslem* OR arab world OR arab states OR arab OR muslim world OR African region OR north africa OR northern africa OR sub-saharan africa OR west africa OR western Africa OR south africa OR southern Africa central asia OR central asia OR east asia OR eastern asia OR south-east asia region OR south-eastern asia OR southern asia OR south asia OR western asia OR west asia OR middle east OR middle east and north Africa OR eastern and southern africa OR west and central Africa OR east asia and pacific OR African region OR south-east asia region OR eastern Mediterranean region OR western pacific region) AND (maternal OR women OR child* OR infant* OR adolescen* OR neonat* OR newborn OR new-born OR under 5 OR under five OR under-five OR under-5 OR child health OR maternal health OR mortalit* OR health OR health status indicator* OR conflict* OR war OR governance OR health systems OR policy OR finance OR financing). Grey literature was searched for the same timeframe, using similar search terms and inclusion and exclusion criteria in Google, Google Scholar, Islamic Development Bank (ISDB), Statistical, Economic and Social Research and Training Centre for Islamic Countries (SESRIC), UNICEF, UNPD, WHO, WHOLIS, World Bank, and government websites.

We found that existing literature on RMNCH and survival was mostly concentrated on Arab countries, which represents less than half of all Muslim nations. Razzak and colleagues explored disparities in mortality and life expectancy between Muslim majority and non-Muslim majority countries and indicated gross national income, literacy rate, access to clean water and level of corruption as key predictors of mortality. A few subnational studies provided mixed results. A report of the Muslim populations in China indicated that the two largest populations of Muslims in the country—the socially accepted and dispersed Hui and the marginalised but localised Uighur (in the Xinxiang province)—had clearly different social, economic and health opportunities. The Hui performed better mainly due to their effective integration into the Chinese community, often through lingual and cultural assimilation. A study of child survival differentials between Muslim and Christian populations in Lebanon found that Muslim children younger than 5 years had comparatively higher mortality rates consistently over a 10 year period and attributed this to poverty and higher levels of fertility among Muslim groups. The 2006 Sachar Commission's report from India found that Muslims relative to Hindus exhibited deficits and deprivation in all dimensions of human development, especially in female education and economic status, yet child mortality levels were significantly lower. In this case, the role of Islam—as contributing to lifestyle, behaviour and practices such as those for personal hygiene—could have contributed to health outcomes. Similarly, diverse findings have been reported of Muslim populations in other studies in India, Bangladesh, Ghana, Israel, and Switzerland.

Added value of this study

To our knowledge, this is the first systematic and comprehensive analysis of reproductive, maternal, newborn, child and adolescent health among all 47 Muslim majority countries worldwide. Our study underscores many key findings among Islamic nations. Muslim nations globally have higher mortality among vulnerable populations relative to non-Muslim countries, and coverage of essential interventions, especially those around reproductive health, prenatal, delivery and labour, and childhood vaccines, are significantly lower. Our findings suggest that structural and contextual factors in these countries could be the leading causes of disparities and poor outcomes. Although widespread conflict, political instability, and insecurity in Organisation of Islamic Cooperation (OIC) countries could also be a contributing driver of adverse outcomes, some evidence suggests that relatively low empowerment of women and young girls, as evidenced by lower literacy rates, higher levels of fertility and younger ages at marriage and could be important contributors to observed differentials.

Implications of all the available evidence

Findings from this study could be used by policy makers, development partners, secretariat of the OIC, and civic society representatives of Islamic countries for tangible actions to improve reproductive, maternal, newborn, child and adolescent health. Concerted efforts should focus on interventions to empower women and young girls, for example, by promotion of delayed onset of marriage and first pregnancy and initiatives to promote female education. Initiatives to resolve conflict and insecurity within and across Islamic countries are critically needed, and should be led by the Muslim countries themselves with support from international stakeholders. Addressing of social deprivation, investments in promotion of equity, and peace negotiations will prevent deprivation and a sense of injustice that breeds insurgency and civil uprisings. A focus on implementation of community-based, outreach, and primary care initiatives as well as social safety nets could help in this regard. Governments should prioritise human development and provision of human resources, funding, infrastructure, and commodities for reproductive, maternal, newborn, child and adolescent health, especially among marginalised populations and in unstable conflict affected areas. Transparent and accountable state governance underlies success in all these initiatives and should be encouraged and supported locally and internationally. Resource sharing from wealthier Islamic countries to poorer and fragile states, facilitated through the OIC and other regional stakeholders, would encourage equity across the Islamic world.

Panel: Origin and premise of Islam

The origins of Islam can be traced back to the heart of Arabian society in 7th century CE.[2] The Quran and Sunnah (the practices and sayings of Prophet Muhammad) form the main sources of its principles and dicta.[3] An estimated 80–90% of the world's Muslims are Sunni, whereas 10–20% are Shia.[4] The two sects, which form the main branches of Islam, disagree as to what is considered the legitimate line of Prophet Muhammad's succession.[3] Nonetheless, they agree on the fundamental Islamic Sharia principles.[5] As a comprehensive regulatory system adhered to by all Muslims (irrespective of various sects), the Sharia's core objective is to promote social justice and individual flourishing through personal hygiene, nutrition, abstinence from harmful substance use, and the fostering of healthy environments.[6,7]

This objective entails establishing external conditions that are necessary for fostering the highest possible development of all members of Muslim society.[8] In this sense, the Sharia extends beyond the context of worship, towards regulating broader political, economic, and social issues.[7] Islam has traditionally merged politics and religion, thus encouraging sectarian politics rather than secular ones, which some might argue makes Islam incompatible with democracy.[31] However, Sharia also seeks to promote freedom and equity within political spheres by prohibiting the abuse of trust, power, authority, and prowess.[9] Furthermore, it seeks to attain economic equity by means of two main systems. The first is a Sharia compliant financial system that encourages entrepreneurship, while ensuring fair play in financial transactions and products. The second is a redistributive system, namely zakat or almsgiving, which requires Muslims with financial capacity to annually allocate 2·5% or more of their net assets to those in need.[10] Finally, the Sharia seeks to enhance social wellbeing by encouraging the building of strong social and marital relationships, and enhancing peace, harmony, benevolence, and trust within the community.[6]

In addition to addressing external factors, the Sharia places importance on the individual, with the goal of promoting self-actualisation and self-fulfilment.[11] It emphasises respect for the body and safeguarding health through personal hygeine, nutrition, abstinence from harmful substance use, and promoting healthy environments.[6] It also emphasises respect for and development of human intellect through education and knowledge-seeking.[12] Overall, the Sharia offers a set of holistic principles that have the potential to enhance social and individual wellbeing in Muslim societies.

Islamic countries have, however, been shown to be more autocratic and more repressive of women's rights,[32] with some commentators attributing the gender inequality in the Muslim world to Islam's patriarchal values.[32–34] Muslim supporters of Sharia law were less likely to be supportive of granting specific rights to women including the right to divorce, the right to equal inheritance, and the right to decide whether to wear a veil.[35] Human rights violations regarding women's sexual and reproductive rights vary across the Islamic world because they are a result of a combination of historical, traditional, social, and economical constructs that have been incorporated into their customary laws.[36] Many academics argue that these methods of female disempowerment stray far from the religious doctrine itself, which can be interpreted as having an egalitarian approach to reproductive rights.[37] Islam, like many other religions, is often invoked by fundamentalists as a justification for violating women's rights. Nevertheless, an indication of the diversity in Islamic perspectives can be seen as many countries have exercised reproductive rights with relatively liberal abortion and family planning laws, namely in Egypt and Tunisia.[38,39]

the maternal mortality ratio dropped by about 44% from 1990 to 2015 (from 385 to 216 deaths per 100 000 livebirths)[3,4] and the under-5 mortality rate declined by 53% (from 91 to 43 deaths per 1000 live births).[5,6] Still, an estimated 303 000 mothers and 5·9 million children younger than 5 years die every year from largely preventable causes.[7,8] More than 95% of these deaths occur in just 75 countries of the world, the so-called Countdown to 2015 countries.[2] Countries that lagged behind were predominantly in south Asia, the Middle East, and Africa.

Several shared contextual factors in these regions are associated with lack of progress. These include widespread poverty, poor socioeconomic and development indicators, and suboptimal health spending.[9–11] Low levels of female literacy and pro-male gender disparities are also commonplace.[9,12,13] Sound and stable governance is crucial for development,[14,15] yet many of these countries experience poor governance, authoritarian regimes,[9] or are in the throes of long standing conflict and insurgency.[16]

Notwithstanding these issues, religion and belief systems and the political context in which they exist, might be contextually important.[17–24] Religious beliefs can affect health outcomes through plausible pathways including sociocultural norms, female empowerment, and gender discrimination at communal or household level.[9,25–30] The Islamic faith is also a common thread across many countries in these regions. With an estimated 2 billion people, Islam is the second largest religion in the world (panel)[2–12,31–39] constituting almost 25% of the population globally, and is most commonly practised in north Africa, south Asia, and the Middle East (figure 1). It is estimated that the 47 countries in these areas—officially designated Muslim countries or those with substantive Muslim majority populations (hereafter also referred to as countries comprising the Islamic world)—are home to about two-thirds of the world's Muslim followers.[25] These largely contiguous Muslim countries constitute one-third (26/75) of Countdown countries and account for some 25% of the current global burden of maternal and child mortality.[3,5]

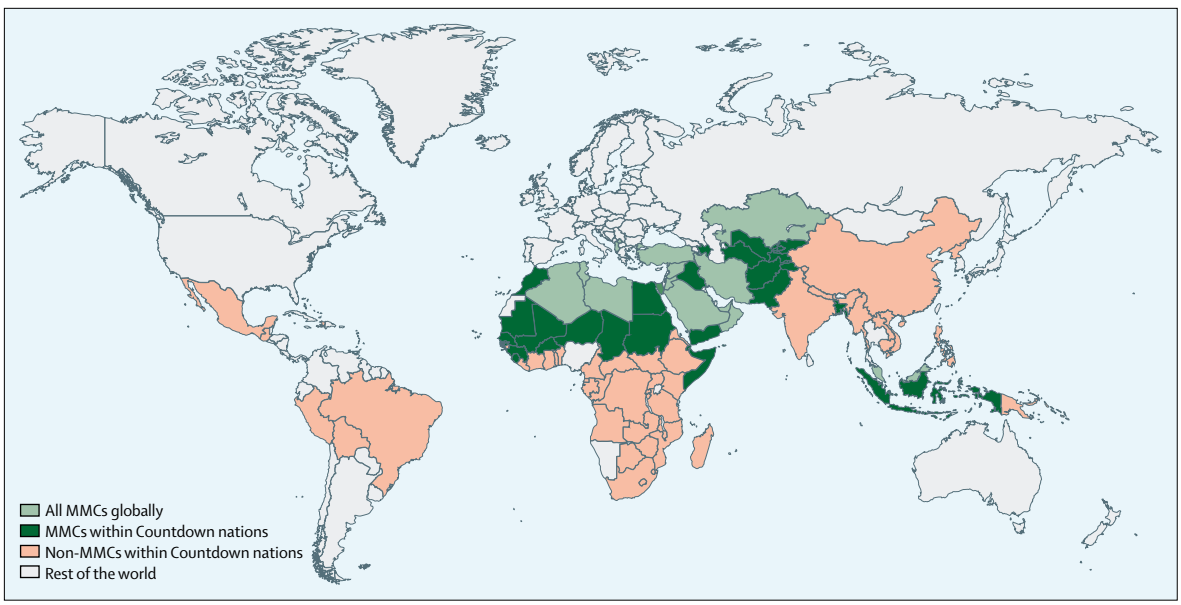

Figure 1: **Geographical spread of 47 Muslim majority and 75 Countdown Countries**
MMC=Muslim-majority country.

To date, the analysis of various contributory factors and their relationship with maternal and child health outcomes in Muslim populations has been largely undertaken in the context of specific countries or populations as opposed to larger regional studies. Evidence from many existing studies as to the status of reproductive, maternal, newborn, child and adolescent health in Muslim countries is at best mixed.[20–22,24,40–43] To our knowledge, no systematic analysis exists of these health indicators among these nations as a collective, or comparisons with other countries at comparable levels of socioeconomic development.

We undertook a comprehensive analysis of the status, progress, and determinants of reproductive, maternal, newborn, child and adolescent health focused on Muslim countries using standard Countdown methods.[44] The specific objectives were to understand the current status and progress in reproductive, maternal, newborn, child and adolescent health in all Muslim countries, and the determinants of child survival among the least developed countries; to explore differences in these outcomes and the key contextual determinants of health between Muslim and non-Muslim countries; and to understand the health service coverage and contextual determinants that differ between best and poor or moderate performing Muslim countries. It should be noted that the broader study aim is to improve the understanding of Muslim countries as a collective, and not to examine the "impact" of Islam on outcomes.

As the world embarks on addressing the Sustainable Development Goals (SDGs), we expect this analysis to potentially guide future practices, decisions, and policies for respective governments, development partners, funders, as well as the political assembly of Islamic nations (ie, Organization for the Islamic Cooperation [OIC]).[45]

Methods

Study design

We identified countries as being Muslim-majority on the basis of two criteria. First, they have substantive Muslim populations based on the proportion of the national population that self-identified their religion as Islam (ie, >50% population).[46] Second, they self-identify as part of the OIC: the political assembly of Islamic countries that was founded to be "the collective voice of the Muslim world".[45] Altogether, 47 countries met this MMC classification (figure 1).[40,45,46] We increased the 50% threshold to 70% for sensitivity and found no differences. Applying the 50% threshold and excluding Kosovo (for which data were unavailable) and Nigeria, the within-Countdown analyses included a total of 74 countries (26 MMCs and 48 non-MMCs). In view of Nigeria's roughly 50–50 split of Muslims and Christians, it did not conform naturally to either study group and was thus excluded to avoid misclassification.

We did an ecological multicountry assessment focused on the 1990 to 2015 MDG period. We did the following subsets of analyses: 1) examined adolescent, maternal, under-5, and newborn mortality, and stillbirth trends between the world and MMCs (n=47); 2) assessed differences in mortality, reproductive, maternal, newborn, child, and adolescent health coverage and determinants between Muslim majority (Countdown MMC, n=26) and non-Muslim majority (Countdown non-MMC, n=48) countries situated within the 74 high burden Countdown to 2015 nations;[2] 3) contrasted factors that differentiated best performing MMCs (n=8) from poor performing (or "other") nations (n=18) within the 26 Muslim-majority high burden countries; and 4) examined determinants of child survival within all MMCs excluding high income

states (n=39). No specific ethics permission was sought for this secondary analysis as the data used were in the public space and had previously had identifying information removed. The institutions that commissioned, funded, or administered the respective primary surveys were responsible for all ethical procedures.

Analysis sets 2 and 3 were constrained to the Countdown countries to ascertain differentials only among high burden and potentially comparable populations. Best performing Muslim countries within Countdown were identified as those that reached their MDG 4 targets (ie, Azerbaijan, Bangladesh, Egypt, Indonesia, Kyrgyzstan, Morocco, Niger, and Senegal). High-income MMCs were excluded from analysis set 4 because they comprise socioeconomically distinct nations with lower mortality rates on average, and thus they would not contribute comparable and meaningful variation to an analysis of determinants.

Data sources and variables

Depending on data availability, our analysis spanned the continuum of care and focused on adolescents (10–19 years), women of reproductive age (15–49 years), newborns (0–28 days), stillbirths (fetal death >28 weeks gestation), post-neonates (1–59 months) and all under-5 children (0–59 months). Multiple data repositories were accessed between Sept 1, 2015 and Dec 6, 2016 to retrieve key variables for this study (table 1).[3,5,7,8,47–67] The indicator list and sources are outlined in table 1. For indicators with multiple sources, we prioritised abstraction as follows: 1) original data collection source; 2) UN data repositories; and 3) the dataset with the most complete time series information. A complete listing of variable definitions, sources, and rationale for the final selected source is included in the appendix (pp 8–18).

Outcomes

We aimed to estimate adolescent, maternal, under-5, and newborn mortality, and stillbirths, and their causes of death, essential interventions coverage, and contextual determinants for all MMCs versus comparative nations.

Statistical analysis

We used best-estimate death counts, national age-specific and cause-specific deaths counts, and population denominators[49] to construct mortality rates for Islamic regions using respective standardised methods as employed by the UN Child Health Estimation Reference Group, the UN Maternal Mortality Inter-agency Estimation Group, and the Institute for Health Metrics and Evaluation.[3,5,68,69] For maternal, under-5, stillbirth, and newborn mortality rates, we analysed trends by time period to reflect stages of MDG progress: 1990–99 (early MDG), 2000–09 (mid-MDG), and 2010–15 (late MDG). It should be noted that adolescent mortality estimates were available for 2013 only. We calculated average annual rates of mortality change (β) and least squares mean estimates (lsm) for the time period using ordinary least squares regression, and test for statistical differences between MMC subgroups using time multiplied by MMC model interaction terms. For health interventions coverage and determinants analysis, we used the most recent (2006–15) national estimate and appropriate population denominator to calculate population-weighted medians for Islamic regions.

	Source
Mortality	
Maternal mortality rate	United Nations Maternal Mortality Estimate Interagency Group (UN-MMEIG)[3]
Child mortality rate (under-5, neonatal, and post-neonatal)	United Nations Interagency for Child Mortality Estimation (UN-IGME)[5]
Stillbirth rate	*The Lancet* Ending Preventable Stillbirths Series study group[47]
Adolescent mortality rate	GBD IHME[48]
Cause of death	
Maternal cause of death	GBD IHME[8]
Child cause of death (neonatal and post-neonatal)	Child Health Epidemiology Reference Group (CHERG)[7]
Adolescent cause of death	GBD IHME[48]
Coverage level of health interventions	World Bank Development Database,[49] UNICEF Global Database,[50] UNICEF Infant and Young Child Feeding Report,[51] WHO/UNICEF coverage estimates for immunisation,[52] WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation[53]
Nutrition: stunting, wasting	UNICEF/World Bank/WHO Joint Malnutrition Report[54]
Conflict	
Battle-related deaths	Uppsala Conflict Data Program[55]
Displaced populations	World Bank Development Database[57]
Terrorism (deaths, injuries, and incidents of terrorist activity)	Global Terrorism Database[56]
Governance	
Governance indicators (control of corruption, government effectiveness, political stability and absence of violence or terrorism, regulatory quality, rule of law, voice, and accountability)	World Bank Development Database[57]
State autocracy–democracy	Center for Systemic Peace Polity IV Project[58]
Freedom in the world: political rights	Freedom House[59]
Environment: frequency of natural disasters	EM-DAT, CRED: International Disaster Database[60]
Foreign intervention: ODA (to child health, reproductive health, and additional reproductive services)	Countdown to 2030 databases[61]
Health systems: density of physicians, nurses and midwives (per 10 000 population)	Global Health Observatory[62]
Population and social determinants: socioeconomics, education, inequity, population, fertility or births, government spending, infrastructure, and telecommunications	World Bank Databases[63] and United Nations Development Programme reports[64]
Policy, law, and legislation	
RMNCAH-specific policies	WHO health policy dashboards[65]
Female protection	World Bank Women, Business and the Law datasets[66]
Girls and women empowerment	Maternal and Child Health Equity (MACHEquity) research program[67]

GBD=Global Burden of Disease. IHME=Institute for Health Metrics and Evaluation. EM-DAT=Emergency Events Database. CRED=Centre for Research on the Epidemiology of Disasters. ODA=Official Development Assistance. RMNCAH=reproductive, maternal, newborn, child, and adolescent health.

Table 1: **Study indicators and source**

See Online for appendix

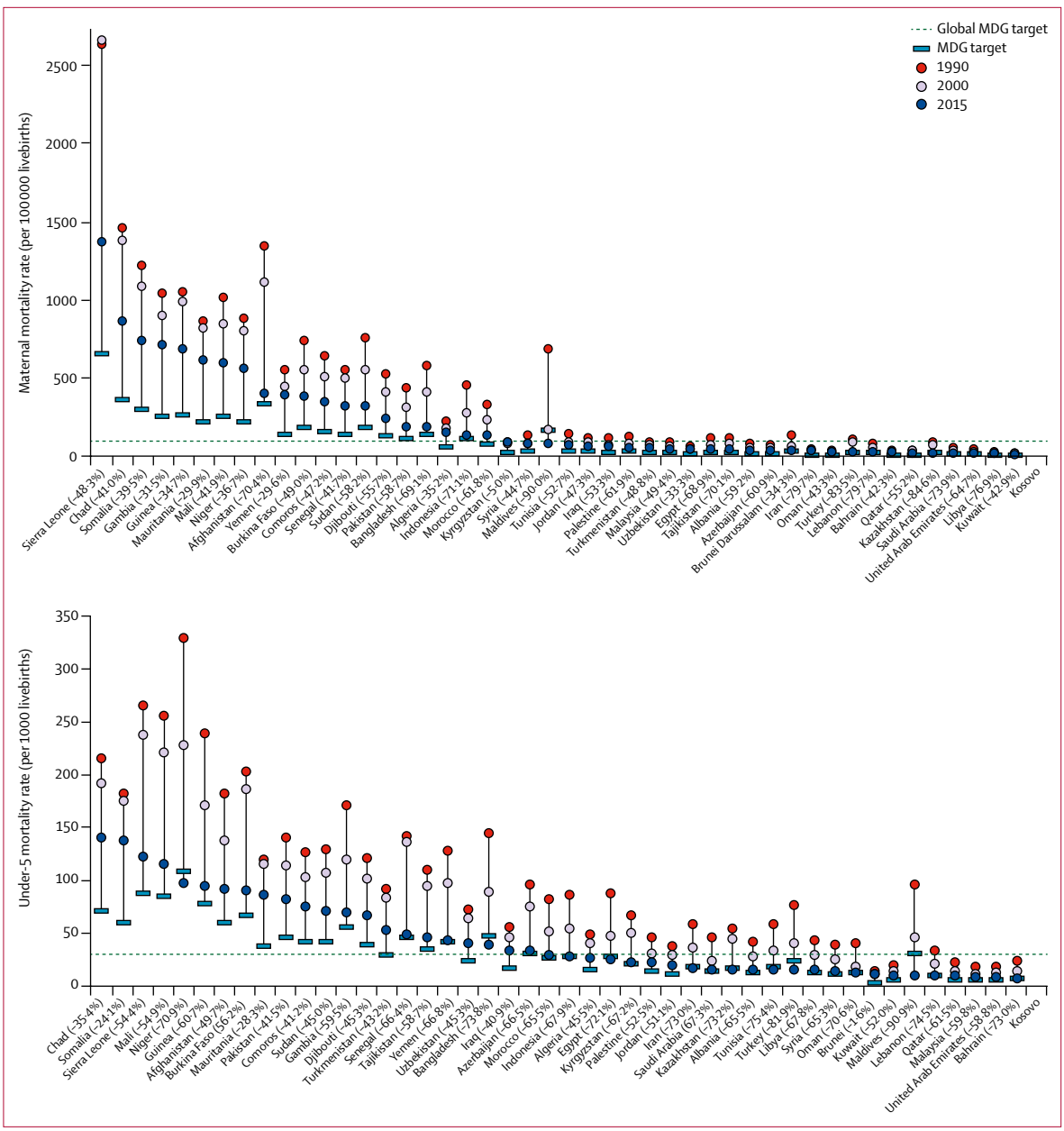

Figure 2: **Maternal and under-5 mortality trends among 47 Muslim majority countries from 1990 to 2015**
Data for Kosovo was not available. MDG=Millennium Development Goal.

Statistical differences were assessed using quantile regression with simplex estimation algorithm and inverted rank-score tests to estimate CIs.[70]

As appropriate, we examined health service coverage and contextual determinant differentials on the entire available Countdown set (ie, 26 Countdown MMCs *vs* 48 Countdown non-MMCs), and subsets of these countries that were one-to-one matched on various criteria. We did a covariate-matched analysis to identify differences between Muslim and non-Muslim countries that existed beyond those explained by confounders. Matching variables included geographical region (using World Bank classification), population density, and the human development index;[57] population density and the human development index were matched within 0·5 SD calipers. We identified 26 matched pairs, with each Countdown MMC linked to one Countdown non-MMC (appendix pp 19–21). We used taylor series linearisation methods to estimate sampling errors and 95% confidence limits (95% CL) of weighted population median estimators.[71]

To understand the major determinants of child survival in MMCs, we adapted well-established conceptual

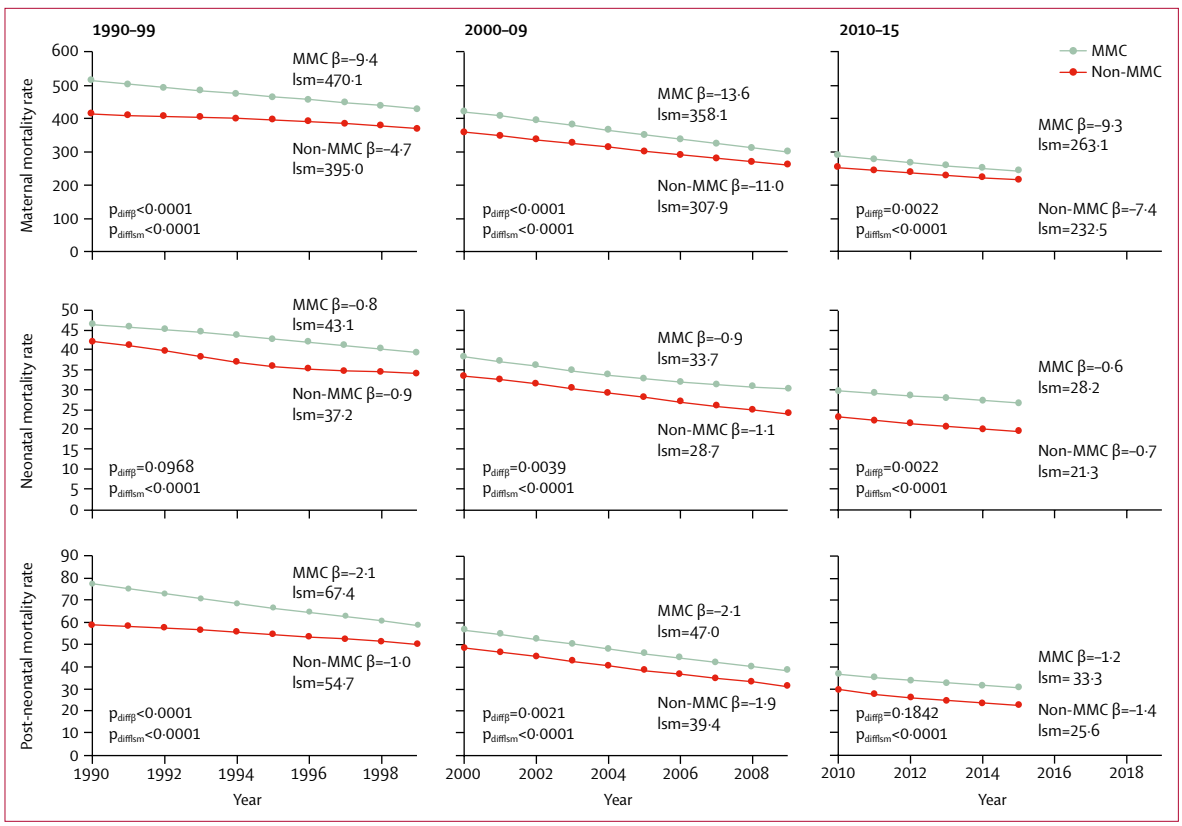

Figure 3: **Mortality trends comparing Muslim and non-Muslim majority countries within the high burden Countdown nations, 1990–2015**
β=average rate of mortality change per year. lsm=cross-time period least squares mean mortality rate. p value for the global test of lsm difference and all pairwise comparisons is equal to $p_{difflsm}$. MMC=Muslim majority country.

frameworks[72,73] and employed a tri-level hierarchical modelling approach.[74] The primary outcomes were under-5 mortality and newborn mortality per 1000 live births among low-income and middle-income (LMIC) MMCs (n=39) assessed annually from 1990 to 2015. At the distal level (level 3), we analysed contextual domains including variables on state governance, climate or environmental conditions, development or infrastructure, exposure to conflict or terrorism, military spending, and international aid. Intermediate level (level 2) variables included individual and household level proxies of socioeconomic status and equity, gender equality, health spending and service use, and access to telecommunications. Proximate determinants (level 1) were grouped into maternal factors (eg, birth spacing and fertility rates), personal illness control (eg, vaccination and illness care-seeking), nutritional deficiencies and adequate environmental conditions (eg, access to improved water and sanitation). Variables are defined in the appendix (pp 8–12). We used linear mixed models with random intercepts and slopes nested within each country using proc hpmixed for sparse data in SAS 9.4. Due to correlation among predictors and the large number of parameter estimates, we used elastic net regression to select statistically significant variables at a threshold of p<0·15 at each level.[75] We entered variables statistically associated with under-5 mortality and newborn mortality at the liberal threshold of p<0·20 in bivariate analysis into multivariable modelling. We imputed missing data using conservative and minimally biased methods;[76] completeness of data is presented in the appendix (pp 22–23). All analyses were done as described with publicly available data from national data repositories and original surveys using SAS version 9.4 and STATA version 13.0.

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

MMCs with the highest maternal mortality burden included Sierra Leone, Chad, Somalia, Gambia, Guinea, Mauritania, Mali, and Niger—each with a maternal mortality ratio (MMR) of more than 500 deaths per 100 000 livebirths in 2015, despite reducing MMR by about half from 1990 to 2015 (figure 2). Relative to Countdown non-MMCs, Countdown MMCs had faster

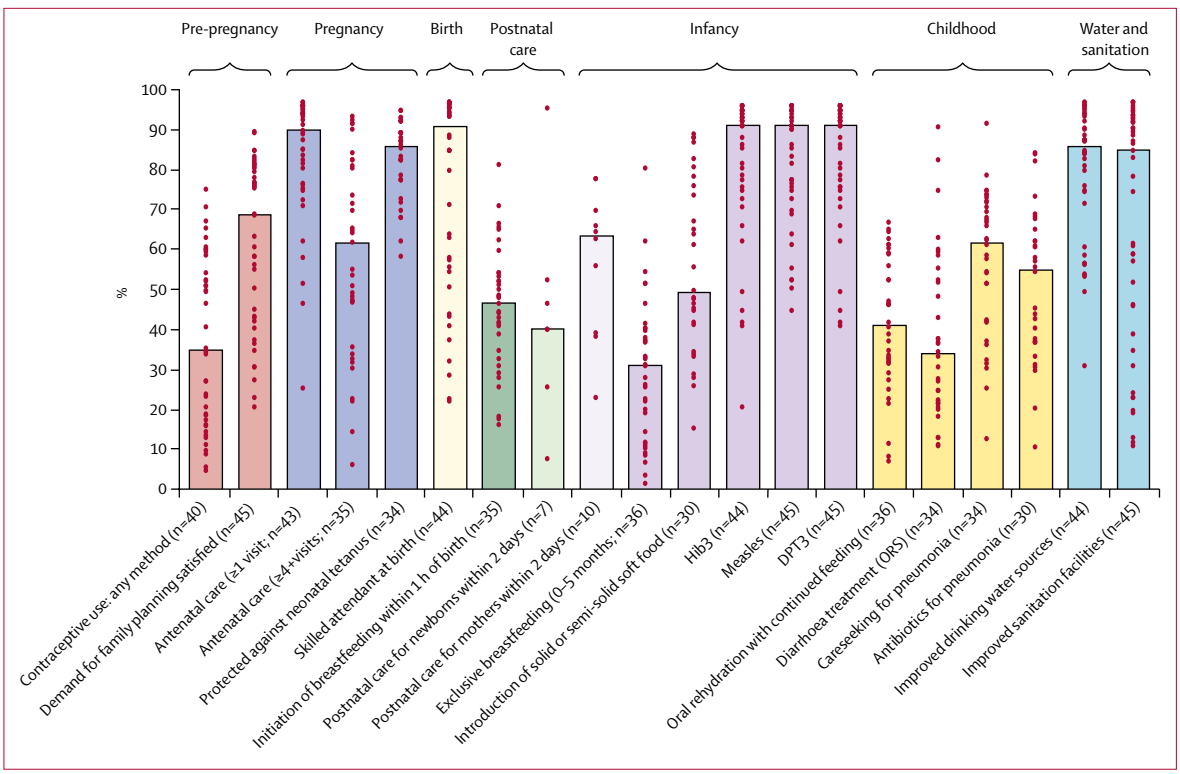

Figure 4: **Coverage of essential interventions across the continuum of care within 47 Muslim-majority countries globally, 2006–15**
Data represents most recent estimate. Bar height indicates median national coverage of selected interventions across 47 Muslim-majority countries. Hib3=*Haemophilus influenzae* type B. DPT3=three doses of diphtheria, pertussis, tetanus vaccine. ORS=oral rehydration solution.

rates of MMR reduction from 1990–2015, with the most acceleration observed in the 2000–09 time period (a reduction of 14 deaths per 100 000 livebirths per year; figure 3). The average MMR gap between Countdown MMCs and Countdown non-MMCs reduced over time, from about 75 deaths per 100 000 livebirths in 1990–99, to 50 in 2000–09, to about 31 in 2010–15. Despite this, Countdown MMCs continued to have significantly higher MMR than did Countdown non-MMCs, averaging about 1·2 times higher across all years and time periods (p<0·0001). MMR trends among all MMCs relative to global patterns are included in the appendix (p 19).

The major causes of death among mothers in MMCs were haemorrhage (34% of all maternal deaths), as well as complications of abortion, miscarriage, and ectopic pregnancy (11%), hypertensive disorders (17%), and indirect maternal deaths (9%); trends were similar between 1990 and 2015 (appendix p 20). Countdown MMCs had a higher proportion of deaths than Countdown non-MMCs from haemorrhage (34% *vs* 29%) and fewer deaths from indirect maternal causes (9% *vs* 12%) in 2015 (appendix p 21).

Compared with all countries worldwide regardless of prevalence of Islam, stillbirth rates and newborn mortality rates were significantly higher in MMCs across all years from 1990–2015 (appendix p 18; p<0·0001). The annual stillbirth rate was on average about 1·3 times higher among Countdown MMCs relative to Countdown non-MMCs across all timepoints (p<0·0001), yet the groups had similar rates of reduction from 2000 to 2015 (appendix p 18). Similarly, newborn mortality rates were significantly higher among Countdown MMCs across all time periods (figure 3; p<0·0001). The annual rate of reduction in newborn mortality rate was similar between Countdown MMCs and Countdown non-MMCs in 1990–99 (β=–0·8 *vs* –0·9; p=0·097), but was slower in Countdown MMCs in 2000–09 (β=–0·9 *vs* –1·1; p=0·004) and 2010–15 (β=–0·6 *vs* –0·7; p=0·002). The major causes of newborn deaths were similar between MMCs and all countries, with preterm birth complications (about 33% of all deaths), intrapartum-related events (about 25%), and sepsis, meningitis, or tetanus (about 20%) as leading causes in MMCs (appendix p 20). Causes of newborn death did not change over time and largely did not differ between Countdown MMCs and Countdown non-MMCs; however, Countdown MMCs had slightly more deaths due to sepsis, meningitis, or tetanus infections in both 2000 and 2015 (appendix p 21). Data for causes of stillbirths were not available.

Under-5 mortality rates decreased about 50% globally from 1990–2015 with notable progress observed in MMCs (figure 2). In 2015, the highest burden MMCs remained Chad, Somalia, Sierra Leone, Mali, Niger, Guinea, and Afghanistan: each had an under-5 mortality rate of about

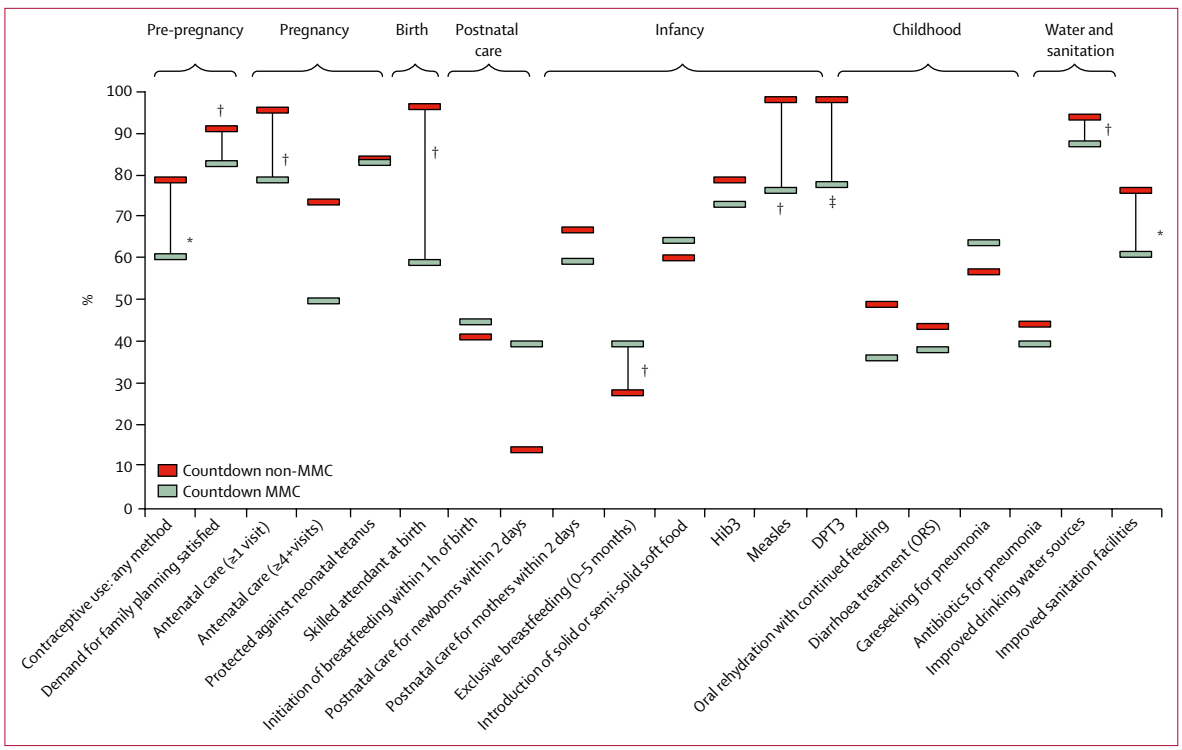

Figure 5: **Weighted median coverage of essential interventions among 26 matched Muslim and non-Muslim majority Countdown countries, 2006–15**
Data represents most recent estimate and estimates were weighted to respective population. Analysis of post-natal care for the newborn and mother was based on small sample sizes and should be interpreted with caution. Hib3=*Haemophilus influenzae* type B. DPT3=three doses of diphtheria, pertussis, tetanus vaccine. ORS=oral rehydration solution. *=p<0·01. †=p<0·05. ‡p<0·10.

100 deaths per 1000 livebirths or more. Several MMCs with moderate under-5 mortality rate in 1990 reached or surpassed their MDG 4 targets by 2015, including Maldives (95 to nine deaths per 1000 livebirths; a 91% reduction), and Turkey, Indonesia, Morocco, Egypt, Azerbaijan, and Senegal. Some high burden MMCs also surpassed their MDG 4 targets, including Bangladesh (144 deaths to 38 deaths per 1000 livebirths; a 74% reduction) and Niger (328 deaths to 96 deaths per 1000 livebirths; a 71% reduction). 18 MMCs did not achieve their MDG 4 targets (figure 2).

Post-neonatal mortality rates among MMCs decreased from about 65 deaths to 26 deaths per 1000 livebirths from 1990–2015. However, relative to all countries worldwide regardless of prevalence of Islam, post-neonatal mortality rates were consistently higher in MMCs across all years (p<0·0001, appendix p 19). Countdown MMCs had significantly higher post-neonatal mortality rates than Countdown non-MMCs across all years from 1990–2015 (figure 3; p<0·0001); the difference between groups was largest between 1990 and 1999 (average 67 *vs* 55 per 1000 livebirths, respectively; p<0·0001) and reduced slightly in subsequent time periods. Rates of decline were more rapid in Countdown MMCs from 1990 to 2009 (p<0·0001) but were about the same as Countdown non-MMCs from 2010 to 2015 (about one death per 1000 livebirths; p=0·184).

The biggest killers of post-neonates in all MMCs in 2015 were diarrhoea (about 20%), pneumonia (about 25%), and malaria and injuries (each about 10%; appendix p 20). From 2000 to 2015, proportional mortality distributions in MMCs changed slightly as post-neonatal deaths from diarrhoea, measles and meningitis dropped about 5% each, while those related to injury increased by almost 4% (appendix p 20). Post-neonates in Countdown MMCs and Countdown non-MMCs are dying from the same causes with the exception of AIDS, which is slightly higher in Countdown non-MMCs (appendix p 21).

All-cause and cause-specific mortality rates among adolescents aged 10–19 years in 2013 are presented in the appendix (p 22). Estimates for 1990 were not available for comparison. Adolescent mortality rates in all countries (81·5 deaths per 100 000 adolescent population, 95% CI 78·3–85·0) are comparable with MMCs (81·1, 70·7–92·8). Although these rates are higher within Countdown countries (about 90 deaths per 100 000 adolescent population), there were no significant differences between Countdown MMCs and Countdown non-MMCs (appendix p 22). However, the major causes of death do vary. The ten most common causes of adolescent mortality globally are presented by subgroup in the appendix (p 22). Among all MMCs, road injuries prevail as the biggest killer of adolescents (10·3 deaths per 100 000 adolescents), followed by intestinal infections,

drowning, self-harm, and lower respiratory infections. Among Countdown MMCs, injuries, intestinal infections, and drowning remain the three most common causes of adolescent deaths; whereas, the fourth and fifth biggest causes are infectious: lower respiratory infections and diarrhoeal disease. Among Countdown non-MMCs, HIV/AIDs is the number one cause of adolescent deaths (9·9 deaths per 100 000 adolescents), followed by road injuries, drowning, intestinal infections and self-harm.

Figure 4 displays coverage of essential interventions across the continuum of care for reproductive, maternal, newborn, child, and adolescent health in 47 MMCs. Median coverage among MMCs is almost 90% or more for antenatal care with a skilled attendant, protection against neonatal tetanus, skilled birth attendance, vaccination for *Haemophilus influenzae* type B (Hib3), measles vaccination, three doses of diphtheria, pertussis, tetanus vaccine (DPT3), and access to improved water and sanitation. Low coverage is noted for contraceptive use, newborn, and child feeding (ie, early initiation, exclusive breastfeeding for 6 months, and timely introduction of solid or semi-solid food), and treatment of diarrhoea with oral rehydration solutions or therapy with continued feeding—each with about 50% median coverage or less. Many interventions show wide disparities across MMCs including contraceptive use (range 5% to 78%), family planning needs satisfied (20% to 93%), antenatal care with a skilled atten-

	All MMCs (n=47)	Within Countdown			Within Countdown MMCs		
		MMC (n=26)	Non-MMC (n=48)	p value	Best performing (n=8)	Moderate or poor performing (n=18)	p value
Human Development Index	0·63 (0·02)	0·59 (0·03)	0·65 (0·03)	0·043	0·63 (0·03)	0·53 (0·02)	0·0036
% of total population rural	49·6 (3·57)	57·3 (3·45)	54·0 (5·97)	0·32	54·4 (5·18)	61·1 (2·81)	0·13
Conflict							
Battle-related deaths (total in 2006–15)	280 603	148 207	35 731	0·0001	489	147 718	<0·0001
Refugees by country or territory of asylum (total in 2014)	13 426 197	3 523 755	3 291 522	<0·0001	367 933	3 155 822	<0·0001
Refugees by country or territory of origin (total in 2014)	9 483 946	5 344 687	3 158 564	<0·0001	74 646	5 270 041	<0·0001
Internally displaced people (total in most recent estimate available)	11 551 501	54 212	26 445	<0·0001	744	7541	<0·0001
Deaths by terrorist activity (total in 2006–15)	116 205	93 905	27 685	<0·0001	5442	88 463	0·0001
Number of individuals injured by terrorist activity (total in 2006–15)	159 911	132 402	36 148	<0·0001	4687	127 715	<0·0001
Number of terrorist incidents (total in 2006–2015)	52 029	45 669	14 622	<0·0001	2518	43 151	0·0001
Governance							
State autocracy–democracy (–10 [hereditary monarchy] to +10 [consolidated democracy])	2·2 (1·60)	3·3 (1·63)	1·7 (3·83)	0·30	4·0 (2·33)	2·3 (2·31)	0·42
Control of corruption (*Z* score)	–0·7 (0·07)	–0·8 (0·08)	–0·5 (0·06)	<0·0001	–0·6 (0·09)	–1·0 (0·12)	<0·0001
Government effectiveness (*Z* score)	–0·5 (0·13)	–0·7 (0·18)	–0·1 (0·16)	<0·0001	–0·4 (0·22)	–1·0 (0·14)	<0·0001
Political stability and absence of violence or terrorism (*Z* score)	–1·2 (0·25)	–1·3 (0·33)	–0·7 (0·13)	0·0034	–0·7 (0·22)	–2·0 (0·25)	<0·0001
Regulatory quality (*Z* score)	–0·6 (0·14)	–0·7 (0·16)	–0·4 (0·07)	0·016	–0·5 (0·22)	–1·0 (0·15)	0·0041
Rule of law (*Z* score)	–0·6 (0·09)	–0·7 (0·11)	–0·3 (0·08)	<0·0001	–0·5 (0·10)	–1·0 (0·12)	<0·0001
Voice and accountability (*Z* score)	–0·7 (0·18)	–0·6 (0·21)	–0·5 (0·47)	0·54	–0·3 (0·26)	–1·1 (0·17)	0·0059
Economy							
Poverty headcount ratio at national poverty lines (% of population)	23·2 (3·69)	25·8 (4·24)	28·0 (4·10)	0·61	21·0 (5·66)	32·8 (3·00)	0·031
Total unemployment (% of total labour force)	8·1 (0·92)	7·8 (1·09)	5·0 (0·56)	0·0072	7·1 (1·36)	8·7 (1·84)	0·34
Youth unemployment (% of total labour force ages 15–24)	19·2 (2·62)	18·2 (3·33)	11·2 (0·78)	0·0021	20·5 (4·90)	15·3 (3·58)	0·30
GNI per capita (US$)	3181·4 (1371·9–4727·2)	1434·8 (1184·3–3358·9)	1954·5 (1523·4–7805·2)	0·87	3240·6 (1183·4–3386·0)	1399·4 (1191·0–1458·8)	0·081
Net ODA received per capita (US$)	19·4 (12·6–44·1)	16·8 (6·48–39·1)	1·5 (-0·70–6·47)	0·26	2·6 (-1·53–25·9)	19·7 (14·2–44·0)	0·75

(Table 2 continues on next page)

	All MMCs (n=47)	Within Countdown			Within Countdown MMCs		
		MMC (n=26)	Non-MMC (n=48)	p value	Best performing (n=8)	Moderate or poor performing (n=18)	p value
(Continued from previous page)							
Health financing							
Total health expenditure (% of GDP)	4·5 (0·52)	4·2 (0·56)	5·4 (0·30)	0·0031	3·7 (0·59)	4·8 (1·07)	0·15
Public health expenditure (% of GDP)	2·0 (0·32)	1·5 (0·23)	2·5 (0·42)	<0·0001	1·4 (0·26)	1·8 (0·42)	0·22
Out-of-pocket health expenditure (% of total health expenditure)	48·7 (3·40)	54·5 (3·11)	42·9 (7·51)	0·0006	54·0 (5·09)	55·2 (3·05)	0·79
ODA to child health per capita (US$)	14·1 (3·16)	14·1 (3·16)	7·2 (3·10)	0·021	9·0 (3·45)	20·7 (3·40)	0·0078
ODA to maternal and newborn health per capita (US$)	26·6 (5·94)	26·6 (5·94)	14·5 (5·83)	0·093	17·9 (6·52)	37·9 (8·88)	0·051
ODA to reproductive health per capita (US$)	5·0 (1·31)	5·0 (1·31)	5·6 (2·62)	0·81	2·6 (0·91)	8·1 (2·31)	0·022
ODA to additional reproductive services per capita (US$)	1·8 (0·45)	1·8 (0·45)	3·9 (1·90)	0·20	1·1 (0·40)	2·8 (0·73)	0·074
Female empowerment and equity							
Age at first marriage (female, mean)	22·5 (0·51)	21·6 (0·51)	22·9 (0·96)	0·017	21·3 (0·75)	22·1 (0·48)	0·33
Fertility rate (average births per woman)	3·1 (0·23)	3·4 (0·33)	2·5 (0·33)	0·011	2·8 (0·30)	4·2 (0·31)	0·011
Adolescent fertility rate (births per 1000 girls aged 15–19 years)	53·9 (5·97)	64·8 (7·95)	36·1 (10·92)	0·0014	64·3 (10·37)	65·5 (13·20)	0·94
Adult literacy rate (% of adults aged 15 years and above)	74·0 (5·17)	68·9 (7·02)	81·1 (6·31)	0·018	76·0 (9·43)	59·6 (4·94)	0·063
Female adult literacy rate (% of females ages 15 years and above)	67·6 (6·20)	64·2 (8·16)	78·4 (7·62)	0·013	73·5 (9·79)	51·8 (5·88)	0·022
Female youth literacy rate (% of females aged 15–24 years)	83·1 (4·63)	78·3 (6·43)	88·2 (4·66)	0·044	87·9 (5·99)	65·6 (4·97)	0·010
Gender inequality index (0–1; closer to 1 is higher inequality)	0·50 (0·02)	0·54 (0·02)	0·41 (0·09)	<0·0001	0·51 (0·02)	0·58 (0·03)	0·038
Gini Index (0–100; closer to 100 is higher inequality)	34·2 (1·13)	33·2 (1·14)	40·2 (2·41)	<0·0001	34·0 (1·20)	31·9 (1·56)	0·22
Health systems resources: density of physicians, nurses and midwives (per 10 000 population)	26·9 (5·08)	19·8 (4·86)	31·2 (4·36)	0·090	15·4 (3·51)	25·4 (10·18)	0·37

Data are weighted mean (SD); GNI and net ODA received per capita are shown as weighted median (IQR); all conflict indicators presented as summary counts and tested as rates (/population denominators) using negative binomial regression. p values test for significant differences between MMCs and non-MMCs within Countdown and between best performing MMCs and other MMCs. N is the number of countries contributing data to estimates. MMC=Muslim-majority country. ODA=official development assistance. GNI=gross national income. GDP=gross domestic product.

Table 2: **Population-weighted basic demographic, economic, education, conflict and social indicators (best estimates for 2015)**

dant (25% to 100%), four or more antenatal care visits (5% to 95%), and skilled birth attendance (22% to 100%). Comparable wide gaps are noted for almost all other interventions. Removal of the seven high-income MMCs did not change these observed trends (appendix p 23).

Countdown MMCs had reduced weighted median coverage of many essential interventions compared with Countdown non-MMCs (figure 5). These included contraceptive use (60% *vs* 79%, p=0·063), family planned needs satisfied (83% *vs* 91%, p=0·045), antenatal care with a skilled attendant (79% *vs* 96%, p=0·023), skilled birth attendance (59% *vs* 96%, p=0·016), measles vaccination (76% *vs* 98%, p=0·045), DPT3 (78% *vs* 98%, p=0·090), and access to improved water (87% *vs* 94%, p=0·014), and sanitation facilities (61% *vs* 76%, p=0·0001). Exclusive breastfeeding (39% *vs* 27%, p=0·045) was higher in Countdown MMCs compared with Countdown non-MMCs. Complete box plots of these median estimates are included in the appendix (p 24).

Among the eight best performing Countdown MMCs (Azerbaijan, Bangladesh, Egypt, Indonesia, Kyrgyzstan, Morocco, Niger, and Senegal), weighted coverage of interventions was significantly greater for contraceptive use (p=0·002), family planned needs satisfied (p=0·067), four or more antenatal care visits (p=0·062), protection against neonatal tetanus (p=0·038), and childhood vaccines (DPT3 [p=0·028] and measles [p=0·014]) relative to the other moderate or poor performing Countdown MMCs (appendix pp 25).

Table 2 presents weighted averages of several contextual determinants among MMCs and within Countdown countries. The human development index is 0·63 on average in all MMCs. Countdown MMCs have lower HDI than non-MMCs (0·59 *vs* 0·65; p=0·043). About 23% of the populations in MMCs live below national poverty lines,

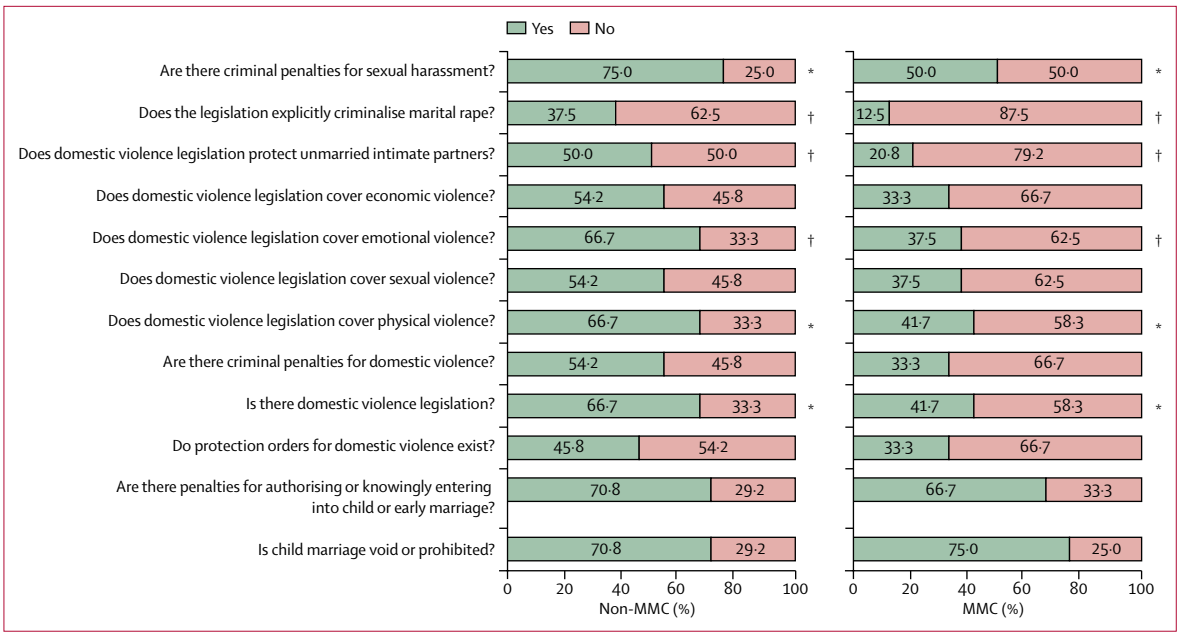

Figure 6: **Policies and legislation on protection of women within 24 matched Countdown countries**
This analysis explores the existence of policies and legislation for protection of women in matched MMC versus non-MMC within Countdown countries. "Yes" refers to the existence of such a policy endorsed at the national level and "no" posits that the country has no such policy in place. MMC=Muslim-majority country. *p<0·01. †p<0·05.

and unemployment rates are 8% among adults and 19% among individuals aged 15–24 years; similarly, the proportion of unemployed adults (p=0·007) and young people (p=0·002) was significantly higher in Countdown MMCs compared with Countdown non-MMCs. GNI per capita and official development assistance (ODA) per capita did not differ between Countdown MMCs and Countdown non-MMCs.

The average number of births per woman was significantly higher in Countdown MMCs (3·4) than Countdown non-MMCs (2·5; p=0·011; table 2), and births among girls aged 15–19 years were twice as high in Countdown MMCs (p=0·001). Average age at marriage is about 22·9 years in Countdown non-MMCs and 21·6 years in Countdown MMCs (p=0·017). Total adult literacy (p=0·018), adult female literacy (p=0·013), and literacy of girls and young women (15–24 years; p=0·044) was significantly lower in Countdown MMCs relative to Countdown non-MMCs. Gender inequalities (favouring men) were increased in Countdown MMCs (p<0·0001) and income inequalities (favouring the rich) were significantly greater in Countdown non-MMCs (p<0·0001). Results from the matched analysis show that legislation and policies protecting women are specifically insufficient in Countdown MMCs relative to Countdown non-MMCs, particularly around domestic violence from unmarried intimate partners (21% *vs* 49%, respectively, have policies), marital rape (13% *vs* 38%), emotional violence (38% *vs* 62%), and physical violence (42% *vs* 66%; figure 6, unmatched results shown in appendix p 28). Additionally, Countdown non-MMCs relative to Countdown MMCs have less policies on women empowerment, including those guaranteeing a girl's right to secondary education and the constitution taking approaches to women's health (figure 7, unmatched results shown in appendix p 29).

Countdown MMCs had lower total (4·2% *vs* 5·4%; p=0·003) and public health expenditure as % of GDP (1·5% *vs* 2·5%; p=0·001) than did Countdown non-MMCs; Countdown MMCs also had higher out-of-pocket expenditure as a percent of total health expenditure (55% *vs* 43%, p=0·001; table 2). ODA to child health per capita is twice as high in Countdown MMCs as Countdown non-MMCs (p=0·021). Differentials in ODA to maternal and newborn health were in the same direction but not significant (p=0·093). ODA to reproductive services did not differ between the two groups. Countdown MMCs generally received more ODA per capita for maternal and newborn health than for child or reproductive health services.

The density of health workers including physicians, nurses, and midwives was lower on average in Countdown MMCs than in Countdown non-MMCs (20 *vs* 31 per 10 000 population, respectively) and does not meet the WHO recommended threshold of 23 workers per 10 000 population among the former (table 2). In both matched and unmatched analyses, there was no apparent difference in the existence of maternal, newborn, and child and adolescent health policies in Countdown MMCs relative to Countdown non-MMCs (appendix pp 26–30).

Countdown MMCs performed significantly worse than Countdown non-MMCs in five governance indicators (control of corruption, government effectiveness, political stability or absence of terrorism, regulatory quality, and

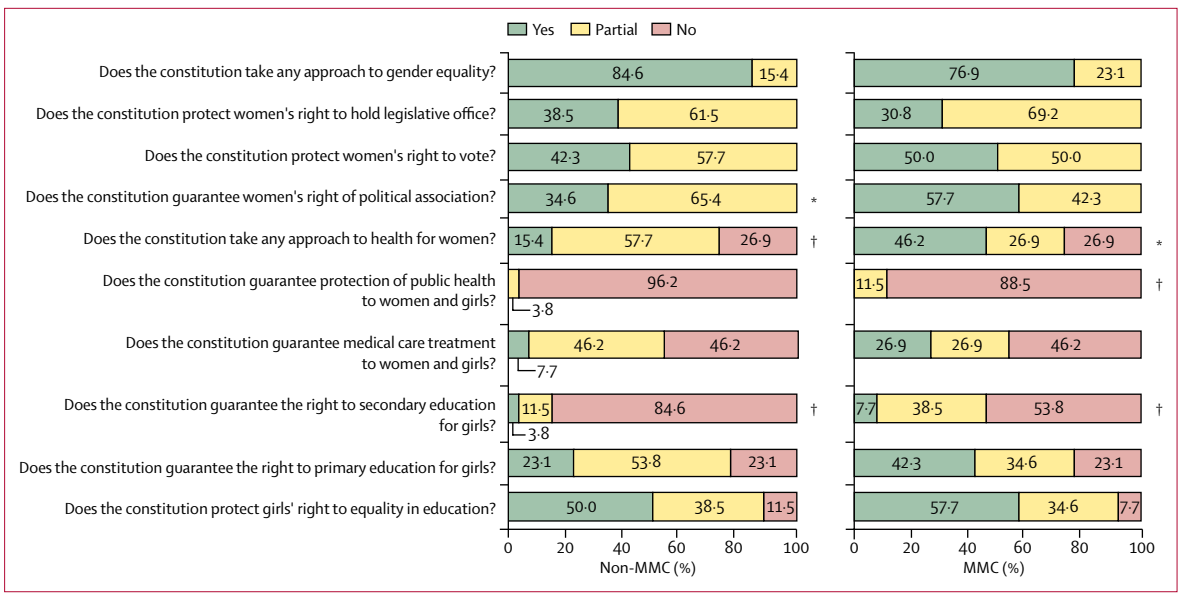

***Figure 7*: Policies and legislation on empowerment of women within 26 matched Countdown countries**
This analysis explores the existence of policies and legislation on the empowerment of women in matched MMC versus non-MMC within Countdown countries. "Yes" refers to the existence of such a policy endorsed at the national level; "partial" refers to existence at the subnational level or incomplete policies; and "no" posits that the country has no such policy in place. MMC=Muslim-majority country. *p<0·01. †p<0·05.

rule of law; table 2). The total number of direct battle-related deaths in MMCs was about 280 603 from 2006–15 and approximately 41% of these were due to terrorist activity. In 2014, MMCs hosted about 13·5 million refugees, and almost 9·5 million civilians left MMCs due to war. Currently, about 11·5 million civilians are internally displaced within MMCs. The total 26 Countdown MMCs had about five times more battle-related deaths than the 48 Countdown non-MMCs (148 207 *vs* 35 731 in 2006–15; p<0·0001). Similarly, Countdown MMCs had more than double the number of internally displaced people and refugees originating from their populations (p<0·0001) compared with Countdown non-MMCs. Countdown MMCs also had at least three times more terrorist incidents, deaths, and injuries from terrorist activity relative to Countdown non-MMCs (p<0·0001 for each indicator; table 2).

Relative to moderate or poor performing Countdown MMCs, the best-performing countries had significantly higher HDI, lower indicators of conflict, fewer internally displaced people and refugees, better state governance indicators, less poverty, less ODA to reproductive, maternal, newborn, child, and adolescent health, lower fertility rates, higher literacy among adults, women, and adolescent girls, and lower gender inequalities (table 2).

Several features of low-income and middle-income MMCs, ranging from broad contextual factors to more proximal measures, had statistically significant independent associations with under-5 mortality rates; these included indicators of conflict, state governance, urbanisation, socioeconomic status and health spending, access to care and care-seeking, maternal factors, nutrition, and improved water and sanitation (table 3). In multivariable analysis, the under-5 mortality rate increased with more refugees originating from a country (β=23·67, p=0·0116), and decreased with better political stability or absence of terrorism (β=–0·99, p=0·0285), political rights or government effectiveness (β=–1·17, p<0·0001), and more urbanisation (β=–1·04, p<0·0001). Reductions in under-5 mortality rate were also related to adjusted increases in intermediary variables including log GNI per capita (β=–4·44, p<0·0001), total adult literacy (β=–1·69, p<0·0001), female adult literacy (β=–0·97, p<0·0001), and female to male enrolment in secondary school (β=–16·05, p<0·0001). High out-of-pocket expenditures on health per capita were associated with increased under-5 mortality rate (β=0·024, p=0·0002). The use of a skilled birth attendant (β=–0·10; p=0·0482) and four or more antenatal care visits (β=–0·38; p<0·0001) had significant positive effects on reducing child mortality. At the proximal level, increased birth spacing (p<0·0001), personal illness control such as measles vaccination (p=0·010), seeking care for acute respiratory infections (p<0·0001) and diarrhoea (p=0·007), increased exclusive breastfeeding (p=0·046), and improved access to sanitation facilities (p=0·107) were important adjusted determinants of child survival. Increased levels of child malnutrition, including stunting (p=0·121) and wasting (p<0·0001), contributed to lower child survival. Collectively, these variables accounted for 82% of the residual variance in under-5 mortality rate from the null (intercept only) model. About 35%, 74%, and 82% of the residual variance was explained by each of the distal, intermediary and proximal models; significant gains in

the distal and intermediate models relative to the proximal indicates the relative importance of variables in these two levels on improving child survival in low-income and middle-income MMCs. These findings were largely similar in the newborn mortality model within which determinants accounted for 44% at the distal level, 83% at the intermediate level, and 88% at the proximal level of residual variance (appendix pp 32–34). Additionally, protection against newborn tetanus (β=–0·021, p=0·0116) and anaemia among pregnant women (β=0·174, p=0·0002) were important to newborn survival.

Discussion

The role of Islam has been in the global spotlight, especially in how it relates to the running of state functions, communal behaviours, and individual practices. Our study of vulnerable populations—adolescents, mothers and their children—in MMCs underscores many important findings with implications for policy.

We found that, despite sizeable improvements in maternal and child survival between 1990 and 2015, MMCs continued to have comparatively higher mortality rates than the rest of the world. Similarly, Countdown MMCs performed poorly in mortality reduction compared with Countdown non-MMCs, and on average, had lower coverage of interventions for reproductive health, prenatal, delivery and labour, and childhood vaccinations. We noted that structural and contextual factors varied considerably between Countdown MMCs and Countdown non-MMCs with the Countdown MMCs

	Under-5 mortality rate from 1990 to 2015 (deaths per 1000 livebirths)	
	Bivariate	Multivariable
Level 3 model, distal: community level variables*		
Conflict		
Terrorism incidents	0·0022 (0·00019 to 0·0042); 0·0324	..
Internally displaced people†	0·016 (0·0041 to 0·0281); 0·0087	..
Refugee populations (by country of origin)‡	17·75 (1·010 to 34·490); 0·0377	23·67 (5·295 to 42·036); 0·012
Governance		
Political stability or absence of terrorism	–0·64 (–1·321 to 0·035); 0·0632	–0·99 (–1·885 to –0·105);§ 0·029
Political rights (functioning government, etc)	–1·19 (–1·601 to –0·788); <0·0001	–1·17 (–1·580 to –0·766);§ <0·0001
State autocracy or democracy	0·21 (0·080 to 0·335); 0·0014	..
Environment: frequency of natural disasters	–0·081 (–0·271 to 0·109); 0·4024	..
Military spending: government expenditure on military	0·059 (–0·054 to 0·172); 0·3044	..
Foreign intervention: official development assistance and aid received, 2 year lag¶	0·12 (–0·207 to 0·456); 0·4606	..
Infrastructure: urbanisation	–0·99 (–1·378 to –0·611); <0·0001	–1·04 (–1·434 to –0·653); <0·0001
% of residual variance explained by covariates‖	..	35%
Level 2 model, intermediate: individual and household level variables**		
Income		
log GNI per capita, 2 year lag	–5·88 (–7·234 to –4·528); <0·0001	–4·44 (–5·834 to –3·041);§ <0·0001
Poverty	0·24 (0·130 to 0·354); <0·0001	..
Income equity: GINI index	–0·031 (–0·084 to 0·146); 0·5979	..
Education		
Female adult literacy rate	–1·70 (–1·985 to –1·410); <0·0001	–0·97 (–1·401 to –0·535);§ <0·0001
Total adult literacy rate	–2·01 (–2·326 to –1·699); <0·0001	–1·69 (–2·132 to –1·249);§ <0·0001
Gender inequality		
Female to male enrolment in secondary school	–9·86 (–17·571 to -2·147); <0·0001	–16·05 (–23·119 to –8·971);§ <0·0001
Women in national parliament	–0·062 (–0·150 to 0·0251); 0·1616	..
Telecommunications access		
Mobile cellular subscriptions	0·0008 (–0·0152 to 0·0167); 0·9252	..
Health spending		
Total health expenditure, 5 year lag	0·77 (0·300 to 1·238); 0·0014	0·39 (–0·107 to 0·884);§ 0·12
Out-of-pocket expenditure on health per capita	0·0079 (–0·0002 to 0·0159); 0·0554	0·024 (0·0116 to 0·0367);§ 0·0002
Health-care service use		
Skilled birth attendance	–0·29 (–0·441 to –0·146); 0·0001	–0·10 (–0·199 to –0·0008);§ 0·048
Antenatal care, ≥4 visits	–1·55 (–1·880 to –1·210); <0·0001	–0·38 (–0·482 to –0·279);§ <0·0001
% of residual variance explained by covariates‖	..	74%

(Table 3 continues on next page)

	Under-5 mortality rate from 1990 to 2015 (deaths per 1000 livebirths)	
	Bivariate	Multivariable
(Continued from previous page)		
Level 3 Proximal: individual and household level variables††		
Maternal factors		
Parity: total fertility rate	3·79 (2·510 to 5·063); <0·0001	..
Birth spacing: demand for family planning satisfied	–0·95 (–1·076 to –0·821); <0·0001	–1·03 (–1·162 to –0·899); <0·0001
Personal illness control		
Preventive: measles vaccine	–0·11 (–0·147 to –0·0651); <0·0001	–0·050 (–0·089 to –0·0103); 0·010
Preventive: DTP3 vaccine	–0·080 (–0·118 to –0·0417); <0·0001	..
Curative: ARI treatment	–0·20 (–0·348 to –0·0468); 0·0092	–0·15 (–0·209 to –0·0874);§ <0·0001
Curative: ORS treatment	–0·18 (–0·370 to 0·00375); 0·0476	–0·099 (–0·171 to –0·0271);§ 0·0070
Nutrition		
Exclusive breastfeeding for 6 months	–0·055 (–0·137 to 0·0274); 0·1830	–0·051 (–0·101 to –0·0010);§ 0·046
Stunting	0·20 (0·0052 to 0·399); 0·0394	0·077 (–0·0203 to 0·174);§ 0·12
Wasting	0·45 (0·143 to 0·763); 0·0004	0·43 (0·275 to 0·589);§ <0·0001
Environmental contamination		
Access to improved water facilities	–0·89 (–1·216 to –0·561); <0·0001	..
Access to improved sanitation facilities	–1·30 (–1·472 to –1·124); <0·0001	–0·20 (–0·452 to 0·0443); 0·11
% of residual variance explained by covariates||	..	82%

Bivariate and multivariable determinants of under-5 mortality from 1990 to 2015 in 39 low-income and middle-income MMCs. Data are presented as β estimate (95% CL); p value. n=1014 for analysis which includes estimates for 39 countries for 26 years spanning 1990–2015 (39 × 26=1014). Variables significant at p<0·20 in bivariate analysis were entered into elastic net selection multivariable analyses. MMC=Muslim-majority countries. DTP3=diphtheria-tetanus-pertussis. ARI=acute respiratory infection. ORS=oral rehydration solution. *Level 3 multivariable model includes all statistically significant (p<0·15) distal variables as listed. †Per 100 000 total population. ‡Per total population. §Variable imputed for multivariable modelling using linear interpolation followed by last observation carried backward and forward. ¶Values divided by 1 billion for presentation. ||Calculated as ([residual variance component of intercept model–residual variance covariate model]/[residual variance intercept model]). **Level 2 multivariable model includes level 3 model plus all statistically significant (p<0·15) intermediate variables as listed. ††Level 1 multivariable model includes level 2 model plus all statistically significant (p<0·15) proximal variables as listed.

Table 3: **Hierarchical mixed modelling results**

often worst off. Poor state governance, conflict, and women and girl's empowerment were some of the major contributors towards child mortality in low-income and middle-income MMCs. The best performing Countdown MMCs (including Egypt and Bangladesh) had higher coverage of family planning interventions and newborn or child vaccinations, and better contextual determinants than moderate or poor performing Countdown MMCs (such as Somalia, Chad, Sierra Leone, and Afghanistan).

Our findings that MMCs face higher rates of death among mothers, children younger than 5 years (both newborn and post-neonatal), and stillbirths relative to Countdown non-MMCs are comparable to a multi-country assessment from Razzak and colleagues,[40] and studies of Muslim populations in China,[41] Ghana,[24] Israel,[23] and India.[20] However, other studies have provided mixed findings.[17,21,22,42,43] Despite better health service usage in some MMCs, coverage for reproductive, maternal, newborn, child, and adolescent health interventions is generally suboptimal across MMCs with less than 50% for contraceptive use, infant and young child feeding and interventions for treating sick children. The specific findings of lower coverage among Countdown MMCs of family planning interventions, antenatal care, skilled birth attendance, and protection of newborns against tetanus and childhood vaccines coverage are reflected in the findings of larger regional studies that have included groups of MMCs.[77,78]

The poor state of maternal and child health in many Muslim countries has also provoked questions about the role of religion and its potential contribution to lack of progress. Existing literature exploring the role of Islam in relation to different issues such as gender inequality, conflict, and democracy points to three types of arguments: the first argument views Islam as the culprit; the second sees structural issues rather than Islam as root causes; and the third takes a middle ground, illustrating how Islam is just one factor among many others. In the case of gender inequality, for instance, some scholars have attributed the unequal status of women in the Muslim world to Islamic patriarchal values.[32–34] Others have emphasised the role of structural factors in MMCs such as economic dependence on oil, lack of responsive democratic systems and the implementation of a strict version of Sharia law.[79,80] Yet others have bridged both sides of the argument, by underscoring the role of Islamic practices alongside other social, economic, political, and cultural factors in promoting gender inequality.[81]

Our study provides evidence that structural factors could well be key drivers of differentials between Muslim and non-Muslim nations. However, the identified

contextual differences could be potentially linked to the specific aspects of the Islamic faith, which ranges from being a religion, to a governing jurisprudence, to a complete way of life in these countries. This is indeed evident from clear differences in reproductive, maternal, newborn, child, and adolescent health outcomes across MMCs with several success stories, especially for reduction in child mortality including Niger, Maldives, Morocco, Azerbaijan, Senegal, Bangladesh, and Egypt whose successes in attaining MDG 4 and MDG 5 have been recognised globally.[82–84] Our study did not specifically explore the role of religion and its implementation guiding specific policies in MMCs nor did the available data permit an evaluation of individual practices of Islam in the context of related outcomes. This might be a subject for future studies. However, there are notable differences between Muslim populations within large countries that might provide some pointers. The fact that socioeconomic outcomes and health status in the Muslim Uighur populations in China are much worse than the Chinese Hui Muslims, underscores the role of sociocultural factors and lack of integration as dominant factors as opposed to the Islamic faith alone.[41]

The observed heterogeneity in health service coverage could be attributed to specific contextual factors, especially issues of adolescent health, women's empowerment, and access to services. Insufficient empowerment of women and lack of social support (eg, from families and friends) can affect accessibility of basic health-care services, including family planning, and can adversely affect overall health and nutrition of the family.[85] Used as proxies of female empowerment—low literacy, high fertility rates, and early marriage of young girls—have been identified as key problem areas among MMCs in this study, and has also been shown in other analyses of Muslim countries.[13] A composite index for women's empowerment developed for African countries found that several MMCs were among the most disempowered countries across domains pertaining to women's attitudes towards violence, their social independence, and the autonomy of their decision making (eg, Niger, Mali, Guinea, Senegal, Morocco, Sierra Leone, and Burkina Faso).[86]

A major cross cutting issue among MMCs is poor governance and lack of accountable and democratic governments. The cyclical deterioration of governance, specifically government effectiveness and accountability, affects health systems performance and outcomes across the board; this has been shown previously in the Arab world[87] and WHO's Eastern Mediterranean region.[88] Therefore, broad governance reform and grass roots democratisation of health and accountability in Islamic countries is an important step towards achieving the SDGs in letter and spirit.[87] Good governance ultimately links to stable social development, effective policies and health systems. Although we found no significant difference overall in the existence of policies for reproductive, maternal, newborn, child, and adolescent health between Countdown MMCs and Countdown non-MMCs, policies or strategies for the protection and empowerment of women were frequently lacking in the former. Additionally, we found very limited information about the actual implementation of policies and accountability that could also vary significantly.

Substantial gaps in coverage of key interventions and consequent differences in mortality rates between Muslim and non-Muslim countries could also be explained by differences in financial investments in reproductive, maternal, newborn, child, and adolescent health programmes. Coverage of interventions can increase rapidly when funding is sufficient, consistent, and targeted;[89] whereas, poorly resourced health systems are associated with low coverage of interventions.[90] Often, households in low-income and middle-income MMCs have high out-of-pocket expenditures and much of the official health spending is dependent on official development assistance, with unsustainable health improvements.[89] It is known that countries with higher out-of-pocket expenditure and lower government expenditure have lower intervention coverage and higher mortality.[91] Politically unstable countries with poor investment in health and social sectors are especially vulnerable to shocks and instability.[92] Responsive and accountable governments are a prerequisite for social sector investments, and sustainable health policies and programming. Our findings of better governance indicators and social sector investments among well performing, yet poor, MMC Countdown countries underscores the importance of these factors as opposed to religion alone.

Insecurity, conflict, and population displacement emerge as common and cross-cutting determinants and sadly, are widespread within MMCs. The solutions and resolutions of many of these conflicts also need to emerge from within the Islamic world and communities themselves. This could be accomplished through addressing underlying root causes of social deprivation, investments in promotion of equity, as well as promoting stability through peace building, tolerance, and reconciliation. Encouraging policy initiatives that focus on community-based, outreach and primary care initiatives are key in reducing deaths of the most vulnerable populations.[93] Community-based services are also preferred in such fragile settings due to accessibility, unrestricted availability, cost effectiveness, and acceptability.[93] Governments and other stakeholders need to combine efforts to ensure provision of human resources, funding, infrastructure, equipment, and supplies for reproductive, maternal, newborn, child, and adolescent health in general and especially in unstable conflict affected areas.

Our findings provide much food for thought and several considerations for policy and planning in the Islamic region, especially through the influential OIC platform. Foremost, a focus on reducing inequities both within and

between MMCs is vital. Considerable advances in the promotion of stable health and health system financing, access to health commodities, transportation systems, and education of women could be made with the availability of adequate funds.[94] Although mobilisation of indigenous resources is important, encouraging and enhancing resource sharing from wealthier resource-rich MMCs to their poor counterparts is an important step. This South–South support is currently not captured in development assessment databases and should be systematically recorded for MMCs.

The major causes of maternal, newborn, and child death in Islamic countries are comparable to previous reports,[68,69,77,95] and effective interventions to address these causes among mothers, newborns, and stillbirths are well known.[47,93] These should be prioritised for scaling up and include implementation of the current global strategy for Every Woman Every Child with a special focus on reducing newborn deaths[93] and the global action plan for pneumonia and diarrhoea (GAPPD).[96] This must be coupled with strategies for addressing adolescent health and nutrition as well as sexual and reproductive health among young women. Some of these strategies such as promotion of exclusive breastfeeding, appropriate nutrition, and early child development are a natural fit within Islamic principles and could also be tied to reaching and supporting the poorest sectors of the population. Existing religious platforms and religious leaders could be used effectively to influence community behaviours and for health and immunisation promotion.[97] This approach has been recently deployed in the midst of conflict to promote childhood immunisation and polio control strategies in Pakistan.[98] At a societal level, politicians and civic society leaders can use their positions to open the dialogue on controversial issues including abortion, in-vitro fertilisation, and genetic screening. Iran is an excellent example of an Islamic nation that has successfully implemented a thalassaemia screening programme with great effect.[99]

In view of social taboos, a lack of access to information, and potential interpretation of Islam in relation to social policy, many MMCs have failed to address the sexual and reproductive health needs of adolescents.[100,101] This situation is made much worse by high rates of illiteracy, school drop outs, and limited mobility. Innovative solutions to improve adolescent health and wellbeing in Muslim populations are needed to overcome the unique challenges and barriers facing this group. Efforts should focus on delaying age at marriage and first pregnancy among adolescents, as well as increasing female education.[102] In addition to the obvious step of banning of female genital mutilation, important steps also include domestic violence prevention, provision of social support and mental health services. Cultural barriers can prevent sick women from travelling alone or being brought to health services and have been shown to be important factors in delayed obstetric care seeking and could be ameliorated by training of additional female community health-care workers or through informational programmes that educate male household members.[103] Many Muslim countries, such as Bangladesh, have indeed made tremendous progress in this regard with specific emphasis on the empowerment of young women, increasing literacy, and prevention of child marriage, and there are demonstrable increases in the participation of young women in all walks of life. Other innovative approaches have made effective use of community-based platforms to address these problems in such settings.[104,105]

Addressing of social determinants of health and the non-health SDGs must be prioritised and coupled with robust monitoring and evaluation systems. The promotion of better reliable and accurate data collection is necessary to completely understand inequalities in these nations; many Arab countries lack reliable reported data for income inequality or available data excludes marginalised or non-citizen populations.[87]

Several important limitations of our study should be underscored. Firstly, our findings might be subject to ecological fallacy and thus results should be interpreted with caution, because trends presented at the national level do not directly translate to associations at the individual level or to subnational differentials. Our analyses did not explore Muslim versus non-Muslim subpopulations within Islamic countries, or that among countries such as India, China, and Nigeria, which have substantial Muslim populations but were less than our stipulated cutoff figure of 50%. Moreover, we did not examine the role of various sects or doctrines in Islam (of which there are 73, the major ones being Sunni and Shia) for the same reason. These are important areas for future work to support and confirm the results of this ecological study. In addition, we were not able to assess the major causes of stillbirths, and it is likely that these could vary between Muslim and non-Muslim nations in view of the different burdens of infections compared with other factors such as poor maternal prenatal care and undernutrition. Due to limitations in data availability from many MMCs, we also could not explore the effects of some variables that might have affected child survival. These include household risk factors such as diet diversity and food insecurity, parental life style factors, including substance abuse and domestic violence, and other health service indicators including quality of care, caesarean-section rates, postnatal care for the newborn and mother, early initiation <1 h of breast-feeding, and low birthweight (<2500 g). However, our models explained more than 80% of the variation in child and newborn survival outcomes, indicating that most of the key predictors were captured.

It should also be noted that though our analyses focused on mortality outcomes in the main, injuries and nonfatal illnesses such as mental health disorders, undernutrition, overweight or obesity, and other non-communicable diseases, are also important considerations in the Islamic context and should be explored in

future studies. The Global Burden of Disease study provides robust and comprehensive country-level burden estimates that could be consulted for such analyses. A limitation that should be noted is that variables included in the quantitative analyses were all retrieved from diverse sources, which vary in input dataset design, data collection methods, and modelling strategies. Although more precise and comparable variables can be obtained from common source surveys, this is not practical across countries. Our assessment of women's and girl's empowerment and gender inequality was undertaken via of a range of well-identified proxy indicators[106] obtained from the World Bank,[63] and the commonly used composite gender inequality scores developed by the UN Development Programme.[64] We also assessed policies, laws, and legislations on these topics from a wide array of reputable repositories,[65–67] which contain the most complete and updated compilation of such information. The consistency in our findings regardless of indicator and data source in our multipronged approach speaks to their robustness and replicability. Worthy of note is the somewhat counterintuitive finding of fewer policies on empowerment of women in non-MMCs relative to MMCs; however, these should be considered in the context of the data collected, which asked only of the existence of policies, rather than their implementation and mainstreaming. Finally, missing time series data was an issue for several contextual determinant indicators and across countries. Although imputation methods were employed to complete data panels for multivariable analysis, our approaches are conservative and reduce risk of type 1 error.[76]

Evidence from this study should be used by global leaders, funders, the OIC, and national government among others to start the conversation around the current realities and challenges enveloping Muslim populations. Furthermore, the posed research considerations should propel further investigations into the determinants and key contextual driving factors of maternal and child health in these countries. As the world transitions from a development agenda focused on survival to one that encompasses sustainability and equitable universal health care, those that are left behind must not be lost. Unequal societies especially with wide disparities in wealth, nutrition, health, and human development are fertile grounds for the growth of rebellion and militancy, especially in young people. Efforts to understand and scale up optimal health and wellbeing of almost two billion Muslims worldwide will prove vital to the achieving the SDGs, including peace building over the next 15 years.

Contributors

ZAB conceptualised the study and NA and ZAB wrote the proposals for funding. Data sources were identified and vetted by NA with support from ZAB. NA led the technical team with analytic support from MK, MM, NB, SA-G, and SM. MK, MM, NB, SA-G, and SM prepared and managed study databases. NA designed and conducted the multivariable analyses. NA led the literature review with support from MK, SA-G, and SM. The full manuscript was first drafted by NA and ZAB, with input from all other authors. All authors reviewed and agreed to the analyses, results interpretation, and write up of the final draft. ZAB is the overall guarantor.

Declaration of interests

ZAB is the co-Chair of the Countdown to 2030 steering committee and a Board member of the Partnership for Maternal Newborn and Child Health. All other authors declare no competing interests.

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