Counting births and deaths 2

Are well functioning civil registration and vital statistics systems associated with better health outcomes?

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In this Series paper, we examine whether well functioning civil registration and vital statistics (CRVS) systems are associated with improved population health outcomes. We present a conceptual model connecting CRVS to wellbeing, and describe an ecological association between CRVS and health outcomes. The conceptual model posits that the legal identity that civil registration provides to individuals is key to access entitlements and services. Vital statistics produced by CRVS systems provide essential information for public health policy and prevention. These outcomes benefit individuals and societies, including improved health. We use marginal linear models and lag-lead analysis to measure ecological associations between a composite metric of CRVS performance and three health outcomes. Results are consistent with the conceptual model: improved CRVS performance coincides with improved health outcomes worldwide in a temporally consistent manner. Investment to strengthen CRVS systems is not only an important goal for individuals and societies, but also a development imperative that is good for health.

Introduction

One of the reasons many countries make substantial yearly investments in civil registration and vital statistics (CRVS) systems is to obtain crucial health intelligence, among many other benefits. That information can and should be used to deliver better health outcomes for the population. But do these investments lead to improved population health, and if so, through which pathways? Moreover, can this effect be shown to be additional to the well-established gains in health from such key drivers as income, education, and equity?

We might expect good CRVS systems to lead to improved health for several reasons. Many societal and individual benefits and entitlements result from birth registration and certification.4,5 Additionally, registration of births and deaths generates information that has substantial policy utility, especially when age of the mother giving birth, age and sex of the decedent, and underlying cause of death are correctly specified.6,7 These benefits have been evident from the time that CRVS systems started to be implemented on a routine basis in England and Sweden around the 18th century, where they undoubtedly contributed to health and socioeconomic development.7

Despite increasing recognition that reliable CRVS systems have a central role in monitoring and assessment of aid effectiveness, and despite the inclusion of birth registration among the universal rights of the child 25 years ago, improvement of population coverage with well functioning CRVS systems has been disappointing.8–10 This disappointment might, in part, be because to build a CRVS system is a long-term public policy investment that has not met the short-term information needs of national governments and potential donors. The dearth of empirical research into the global state of CRVS systems, and into the cost-effectiveness, advantages, and limitations of investment in strengthening of CRVS systems, compared with household surveys and facility-based information systems, have all probably contributed to continued inadequate investment.11,12

Search strategy and selection criteria

The search included a search of websites of international health and development agencies with mandates covering aspects of civil registration and vital statistics (CRVS), a search of relevant electronic databases (PubMed and Google Scholar), scanning of references lists from relevant published studies, study of conference proceedings, and direct contacts with technical and in-country experts for references to relevant publications and grey literature. Preference was given to papers with a focus on low-income and middle-income countries and that addressed CRVS in a systemic way. Exclusion criteria were a reference period before 2000 and the production of vital statistics from sources other than the civil registration system.

Key messages

- Well functioning civil registration and vital statistics (CRVS) systems directly benefit individuals and policy, and are independently and statistically significantly associated with better health outcomes
- Ecological analyses show that CRVS performance coincides with good health worldwide, irrespective of income and other factors likely to affect health status
- Well functioning CRVS systems generate crucial information for public health policy, and ensure entitlements and access to services through provision of legal identity to individuals and families
- Greater investment in CRVS systems should be seen as a driver of human development, not only a result of it
In this Series paper, we discuss whether countries that invest to improve their CRVS systems would see returns in terms of improved health. We detail mechanisms by which this improvement in health might occur, and show that well functioning CRVS systems positively correlate with key health indicators, independent of other factors. This association is important new evidence in support of calls for greater, and more urgent, investment to strengthen CRVS systems.13

Associations among CRVS, health, and development
On the basis of a synthesis of existing scientific literature and expert knowledge, we identified a system of pathways for a conceptual model describing the outcomes of a well functioning CRVS system, and the benefits those outcomes bring to individuals and societies (figure 1). These pathways connect CRVS systems to social inclusion, equity, and health via identity, entitlements, access, and information.

Figure 1 presents a general schematic of pathways by which CRVS systems might affect, and be affected by, various components of health and social development. Registration of infants at birth enables access to rights, entitlements, and benefits2,14,15 by establishment of legal identity and family relationships. Proof of identity enables people to claim inheritance, insurance benefits, spousal or partner pension rights, and legal entitlements such as land tenure, and to receive compensation entitlements. Additionally, proof of identity is important to claim nationality either in one’s country of birth or that of one’s parents.16 The multifaceted outcomes of strengthened CRVS are central to the World Bank Global Civil Registration and Vital Statistics Scaling Up Investment Plan 2015–2024.13

Figure 1: Pathways of civil registration and vital statistics (CRVS) effects
CR=civil registration; VS=vital statistics.

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Figure 1: Pathways of civil registration and vital statistics (CRVS) effects
CR=civil registration; VS=vital statistics.
Civil registration has well documented links to legal entitlements and access to services. Although registration of birth does not guarantee access to education, health, social protection, or citizen participation, without a birth certificate those fundamental rights can be beyond reach. People—especially children—with registration documentation are less vulnerable to statelessness and associated risks. Proof of age enables prosecution of perpetrators of crimes against children, such as child trafficking, sexual offences, early recruitment into the armed forces, child marriage, and child labour. Proof of birthplace and parentage directly enables citizenship, and might be fundamental to efforts to make health coverage universal. Availability of legal proof of marriage and divorce is especially important for female heads of household and the families they support. For example, proof of marriage enables access to widows’ pensions or broader public services, such as education and health. Additionally, proof of marriage can help women to obtain nationality or at least residency in a country and, in some societies, protect their rights of access to, and guardianship of, children.

Through entitlements and access, non-discriminatory civil registration can promote social inclusion and contribute to reduced gender and economic inequalities. Individuals with legal identities can fully participate in the modern economy, open bank accounts, take on loans, purchase property, and invest in businesses. Possession
of a birth certificate can be a determining factor to break the cycle of poverty. A citizenry of individuals with legal identities is likewise more likely to be aware of its rights and entitlements, to hold authorities to account, and to participate in political processes, vote in elections, and stand for electoral office. In short, birth registration makes individuals more visible, and the state more accountable for provision of health, education, other services, safety nets, and legal protection.

The vital statistics produced by civil registration provide planners with essential epidemiological intelligence to promote and protect population health. These data guide policy reforms designed to reduce disease burden, and can help to improve allocative efficiency and effectiveness of health systems. Two examples have been the role of vital statistics in stimulation of epidemiological research into causes of increasing lung cancer mortality in Britain and other countries immediately after the Second World War,\textsuperscript{21–24} and in assessment of population-level interventions against road traffic injuries two decades later.\textsuperscript{25,26} In both cases, the extent, pattern, and trend of mortality was discernible from vital statistics, as was the effect of subsequent population-level interventions. Arguably, reductions in premature death after introduction of policies limiting population exposure to hazards such as tobacco and drink driving would have taken much longer without evidence that well functioning CRVS systems provided.

These benefits probably emerge over differing time-scales, which are not depicted in figure 1. For example, marriage certification, death registration, and improved cause-of-death certification could begin to show benefits almost immediately. Likewise, evidence suggests that birth registration provides short-term benefits to individuals and societies. Two notable examples are that children registered at birth are more likely to be immunised,\textsuperscript{27} and that registered children can be more easily identified and protected when separated from their parents—a benefit that is especially important during humanitarian emergencies.\textsuperscript{28,29} Other positive effects of birth registration, however, might take several years to materialise at the individual level. Similarly, increased access to health services, financial inclusion, and use of protected entitlements might gradually emerge over years or even decades. The confluence of all of these benefits at individual and societal levels might reasonably be expected to lead to sustainable improvements in human development, owing to increased opportunity for individuals to participate fully in society and generation of health intelligence to reduce risks to health.

**Measurement of the association between CRVS performance and health outcomes**

If the hypothesised health benefits of CRVS are true, then association between CRVS performance and health outcomes should be measurable with appropriate metrics. However, pragmatic constraints, limitations of available data, and difficulties in identification of valid measurement instruments rule out strong analytic designs for causal inference, such as quasi-experimental approaches or instrumental variables to assess the hypothesised relation. Measurement is thus restricted to observational data analysis at the population level, which might have various sources of bias. We used a composite metric of national CRVS performance known as the vital statistics performance index (VSPI),\textsuperscript{30} and compared it with national estimates of healthy life expectancy (HALE), maternal mortality ratio (MMR), and child mortality risk ($q_0$),\textsuperscript{31–33} with controls for confounding (panel).\textsuperscript{34–36}

### Table 2: Health outcomes analysed

<table>
<thead>
<tr>
<th></th>
<th>Definition</th>
<th>Mean (SD)</th>
<th>Source</th>
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<tbody>
<tr>
<td>Healthy life expectancy (HALE)</td>
<td>Average expected duration of life in good health, taking into account mortality and disability</td>
<td>62·50 (4·67)</td>
<td>Salomon et al (2012)\textsuperscript{31}</td>
</tr>
<tr>
<td>Maternal mortality ratio (MMR)</td>
<td>Number of pregnancy-related deaths per 100 000 livebirths</td>
<td>30·20 (45·13)</td>
<td>Lozano et al (2012)\textsuperscript{32}</td>
</tr>
<tr>
<td>Child mortality risk ($q_0$)</td>
<td>Probability of death before age 5 years</td>
<td>0·029 (0·029)</td>
<td>Wang et al (2012)\textsuperscript{33}</td>
</tr>
</tbody>
</table>

### Table 3: Covariates

<table>
<thead>
<tr>
<th>Definition</th>
<th>Mean (SD)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log-GDP per capita</td>
<td>9·11 (0·94)</td>
<td>James et al (2012)\textsuperscript{34}</td>
</tr>
<tr>
<td>Urbanisation</td>
<td>0·62 (0·20)</td>
<td>UN World Urbanisation Prospects\textsuperscript{35}</td>
</tr>
<tr>
<td>Health system access</td>
<td>7·92 (4·04)</td>
<td>Global Burden of Diseases 2013\textsuperscript{36}</td>
</tr>
<tr>
<td>Total contraceptive prevalence</td>
<td>0·44 (0·14)</td>
<td>Global Burden of Diseases 2013\textsuperscript{36}</td>
</tr>
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</table>

GDP=gross domestic product.
A modest, but robust and consistent correlation exists between VSPI and health indicators across country-years. HALE is high and MMR and 5q0 are low among countries with improved CRVS performance. The ecological association between the VSPI and HALE is shown in figure 2. On average, HALE was estimated to increase by 0.044% with each unit increase in VSPI on a 100-point scale (coefficient 1.044 on a 0–1 scale; 95% CI 1·020–1·068; p<0.0005). The regression indicates that if worldwide CRVS performance was high (0·9) rather than at its worldwide average based on the 144 countries or territories with available data (0·591), average HALE would increase by nearly 1 year (63·1 years vs 62·3 years).30 MMR and 5q0 are similarly associated with VSPI. Countries with high VSPI values have low MMR (0·721; 95% CI 0·508–1·023; p=0·067) and 5q0 values (0·418; 95% CI 0·367–0·470; p=0·002). The model results are presented in more detail in table 4.

The association between VSPI and health indicators is not likely to be due to confounding. Marginal regression models were used to measure the ecological association between VSPI and health outcomes and to control for confounding (see appendix for a more detailed description of the modelling strategy). Controlling for the four covariates, HALE is on average high, and MMR low, among countries with high VSPI values. Figure 2 shows the persistence of the association among countries stratified into low, medium, and high gross domestic product (GDP), showing that the ecological association exists irrespective of GDP. Statistical analyses show a similar trend when the full gradient of GDP, other covariates, and time-related confounding are accounted for (table 4).
Figure 3: 5-year, 10-year, 15-year, 20-year, and 25-year lead of healthy life expectancy (HALE) compared with vital statistics performance index (VSPI), stratified by gross domestic product (GDP)
The right-hand columns.

and civil registration and vital statistics (CRVS) performance

Regression results for 5-year, 10-year, 15-year, 20-year, and 25-year leads* of health outcomes

Table 5: Original outcome variables were log-transformed (logit for 5q0); coefficients and CIs have been back-transformed. dependent variable (HALE, MMR, or 5q0) in the left-hand columns and the independent variable (CRVS performance) in the right-hand columns. *Lead refers to future values of the variable considered. Year-specific and overall intercepts, coefficients for covariates not shown. 

<table>
<thead>
<tr>
<th>Series</th>
<th>Coefficient (95% CI)</th>
<th>p value</th>
<th>Coefficient (95% CI)</th>
<th>p value</th>
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</thead>
<tbody>
<tr>
<td>Health outcomes</td>
<td>CRVS performance</td>
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<tr>
<td>Healthy life expectancy (HALE)</td>
<td></td>
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<tr>
<td>5-year</td>
<td>1.03 (1.014–1.063)</td>
<td>0.002</td>
<td>1.03 (1.012–1.068)</td>
<td>0.005</td>
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<tr>
<td>10-year</td>
<td>1.04 (1.015–1.066)</td>
<td>0.002</td>
<td>1.03 (1.002–1.065)</td>
<td>0.035</td>
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<tr>
<td>15-year</td>
<td>1.04 (1.020–1.074)</td>
<td>0.000</td>
<td>1.03 (0.997–1.065)</td>
<td>0.077</td>
</tr>
<tr>
<td>20-year</td>
<td>1.05 (1.024–1.081)</td>
<td>0.000</td>
<td>1.02 (0.989–1.068)</td>
<td>0.156</td>
</tr>
<tr>
<td>25-year</td>
<td>1.04 (1.018–1.078)</td>
<td>0.002</td>
<td>1.02 (0.989–1.068)</td>
<td>0.168</td>
</tr>
<tr>
<td>Maternal mortality ratio (MMR)</td>
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<tr>
<td>5-year</td>
<td>0.77 (0.542–1.107)</td>
<td>0.16</td>
<td>0.76 (0.508–1.137)</td>
<td>0.012</td>
</tr>
<tr>
<td>10-year</td>
<td>0.87 (0.574–1.32)</td>
<td>0.196</td>
<td>0.82 (0.533–1.264)</td>
<td>0.371</td>
</tr>
<tr>
<td>15-year</td>
<td>0.838 (0.570–1.234)</td>
<td>0.371</td>
<td>0.934 (0.576–1.514)</td>
<td>0.780</td>
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<tr>
<td>20-year</td>
<td>0.911 (0.602–1.379)</td>
<td>0.659</td>
<td>0.985 (0.558–1.740)</td>
<td>0.960</td>
</tr>
<tr>
<td>25-year</td>
<td>1.031 (0.665–1.537)</td>
<td>0.958</td>
<td>0.982 (0.505–1.907)</td>
<td>0.956</td>
</tr>
<tr>
<td>Child mortality risk (5q0)</td>
<td></td>
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<tr>
<td>5-year</td>
<td>0.425 (0.367–0.485)</td>
<td>0.015</td>
<td>0.421 (0.358–0.486)</td>
<td>0.018</td>
</tr>
<tr>
<td>10-year</td>
<td>0.424 (0.362–0.488)</td>
<td>0.020</td>
<td>0.429 (0.356–0.504)</td>
<td>0.064</td>
</tr>
<tr>
<td>15-year</td>
<td>0.413 (0.349–0.480)</td>
<td>0.011</td>
<td>0.429 (0.356–0.525)</td>
<td>0.161</td>
</tr>
<tr>
<td>20-year</td>
<td>0.410 (0.343–0.480)</td>
<td>0.013</td>
<td>0.452 (0.387–0.551)</td>
<td>0.344</td>
</tr>
<tr>
<td>25-year</td>
<td>0.435 (0.363–0.509)</td>
<td>0.086</td>
<td>0.447 (0.349–0.548)</td>
<td>0.304</td>
</tr>
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</table>

Table 5: Regression results for 5-year, 10-year, 15-year, 20-year, and 25-year leads* of health outcomes and civil registration and vital statistics (CRVS) performance.

Lag-lead analysis

A strong association exists between CRVS performance and delayed health outcomes. Improved CRVS systems are expected to affect health and development gradually, in addition to their more immediate benefits. This gradual effect is expected to produce a measurable ecological association with the leads, or future values, of the outcomes relative to VSPI (figure 3). Irrespective of GDP, VSPI is closely associated with HALE in the future (table 5). A similarly strong association exists between future values of 5q0 and VSPI. The future values of MMR, however, are not associated with VSPI.

The lag-lead analysis is likewise generally consistent with the conceptual model in the reverse direction (ie, when delayed VSPI is used instead of delayed outcomes). A mechanism by which CRVS could be associated with previous health outcomes would be difficult to imagine according to the pathways specified in our conceptual model. Consistent with this idea, future CRVS performance was not statistically significantly associated with past health outcomes in most cases, although the 5-year lead of the VSPI was associated with HALE and 5q0 and the 10-year lead was associated with HALE (table 5).

These ecological analyses show that CRVS performance coincides with good health worldwide, irrespective of income and other factors. These associations occur in patterns that are expected according to the theory that population health status is improved when registration systems are strong, and that improved registration systems precede observable improvements in health.

Role of CRVS systems in population health

On the basis of the CRVS data and health outcome measurements for 144 countries during the past 33 years, we show that well performing CRVS systems consistently co-occur with improved health, irrespective of a population’s wealth, level of urbanisation, health system coverage, or contraceptive prevalence. We likewise expect CRVS performance to have a measurable association with future health outcomes, and we show that ecological data are consistent with these expectations.

Study limitations

Several limitations will need to be considered. First, VSPI is based on mortality registration alone, so our measure of CRVS performance might be underestimated in countries with systems that successfully register births but not deaths (eg, Botswana). If the same countries have poorer than expected health compared with other countries in this analysis, the statistical associations might be overestimated. Second, measurement error might weaken the representativeness of controls used in this analysis, and thus residual confounding might be a concern. However, we did sensitivity analyses to show that measurement error in the outcomes is less of a concern. The same health outcomes measured with different methods (UN estimates of 5q0 and life expectancy at birth50) yielded almost identical regression coefficients (appendix).

Third, unmeasured confounding, such as legal respect for fundamental human rights, could potentially explain the ecological association. Many of the strongest drivers of population health were not included in this analysis in the interest of including only unique covariates that simultaneously affect CRVS systems and health. Other covariates, such as population-level educational attainment, represent country variation that we believe is adequately captured by the existing covariates. Fourth, countries in this analysis were modelled as independent of one another, although they might not be (eg, spatial correlation of neighbouring countries was not considered). This assumption could have led to underestimates of uncertainty. Fifth, the outcome variables in the analysis are model-based estimates, and the models that produced them used (to some extent) vital statistics as an input. The possible endogeneity presented by this circular relation might bias our estimates, although theoretically will affect only uncertainty about outcomes among countries with low CRVS performance. We tested sensitivity to this potential problem (appendix) and showed that, when only the subset of country-years with reliable CRVS data are included (in this case, observations in the upper
needed to explain the inconsistency, we note that adult controlling for covariates. Although further research is specifically pathway, and should be investigated further. 

The ecological evidence is not unequivocally consistent with theory. Sensitivity analyses were done to investigate the relation of CRVS performance with other health outcomes. Although in nearly all cases the results were as expected, one apparent inconsistency is worth noting. Adult mortality (one alternative health outcome) was not statistically significantly associated with VSPI after controlling for covariates. Although further research is needed to explain the inconsistency, we note that adult mortality had no measurable association with health service access or contraceptive prevalence. This result was not recorded for any other outcome. One possible explanation is that the mechanisms through which these factors affect overall levels of adult mortality are sufficiently explained by the other covariates, and that their redundant appearance in the model detracts from the association that would otherwise be measured with VSPI. Some empirical evidence supports this explanation: the coefficient on VSPI changed only slightly with the exclusion of non-significant covariates, but the p value decreased substantially (coefficient 0.458; 95% CI 0.416–0.501; p = 0.055).

Evidence from the lag-lead analysis, although compellingly supportive of an association between CRVS and health outcomes, is not wholly consistent. Our results for future MMR and short-term leads of VSPI (compared with past HALE and \( \hat{Q}_0 \)) were contrary to the conceptual model. We can only speculate about the meaning of these inconsistencies. The observation that future MMR was not associated with previous VSPI implies that additional complexity of non-health system factors exists within this specific pathway, and should be investigated further. With regard to past HALE and \( \hat{Q}_0 \), development of a CRVS system might precede our ability to measure its performance. Therefore, the short-term association between future VSPI and past HALE or \( \hat{Q}_0 \) might be consistent with our conceptual model.

Statistical analysis of this nature should be interpreted appropriately. The regression is not meant to explain most variation in health outcomes, and should not be interpreted as doing so. The objective is to investigate whether an unconfounded association exists between CRVS performance and health outcomes to establish empirical evidence for the associations we posit. Even so, the analysis described above has limitations. Although we do not claim to have established causal relations between CRVS and health outcomes statistically, we believe that our conceptual model realistically describes the mechanisms through which well functioning CRVS systems can contribute to health.

**Conclusion**

Limitations notwithstanding, our analysis contributes important new evidence to support the hypothesis that well functioning CRVS systems not only have direct benefits for individuals and for policy-making processes that use vital statistics, but also contribute to improved population health outcomes. In addition to the crucial value of registration of vital events for promotion of human rights and sustainable development, we suggest that action to strengthen CRVS should not be merely a characteristic of development efforts, but rather a key driver of them. Through improved CRVS systems, people making resource allocation decisions have the opportunity to simultaneously create policy-essential data and enhance individual and collective wellbeing. Countries, regional development partners, and civil society alike should thus derive further motivation from knowledge that strengthening of CRVS systems is not only an important goal for individuals and societies, but is also good for health and development.

**Contributors**

CAZ and ADL conceived the idea for the series and developed the outline for the series, including this paper. DEP and PWS prepared the first draft of the paper on the basis of initial inputs from the rest of the group. DEP did the statistical analyses. All authors provided feedback, additional new inputs and suggestions, and reviewed the final manuscript.

**Declaration of interests**

We declare no competing interests. The views expressed herein are those of the authors and do not necessarily reflect the views of the United Nations.

**References**


