Can Indirect Estimation Methods and the Medical Officer of Health Reports 'Correct' Distorted Infant Mortality Rates Reported by the Registrar General? The Case of London, 1896–1911*

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Abstract

The Registrar General's Returns are an integral source for historical demographers. Concerns have been raised, however, over the geographical accuracy of their pre-1911 mortality figures when institutional deaths were not redistributed to place of residence. This paper determines the extent of the distortions caused by institutional mortality in the context of aggregate infant mortality rates for London's registration sub-districts. The potential of two alternative methods to 'correct' these distortions is then assessed. The first method uses indirect estimation techniques based on data from the 1911 Fertility Census, and the second exploits the rich detail available from the Medical Officer of Health reports. Through narrowing the focus to seven London registration sub-districts over the years 1896–1911, it is shown that both suggested alternative methods remove the institutional mortality biases found in the Registrar General's figures, yet they come with their own limitations.

Introduction

Census and vital registration datasets are fundamental components of a historical demographer's toolkit, yet they are not without their problems. In England and Wales, the Registrar General's Returns are a key source, providing weekly, quarterly and annual figures of vital statistics. The first Registrar General's report was published in 1839, although births, deaths and marriages, as well as notifications of certain infectious disease morbidity and mortality, were registered and collated from 1837.[2] These statistics were reported at a number of geographical scales, the smallest of those being registration sub-districts (RSDs). As a consequence, the Registrar General's returns have been used by historical demographers for decades to explore aggregate patterns of demographic measures and processes in nineteenth and twentieth century England and Wales.[3]

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2 E. Higgs, *Life, Death and Statistics: Civil Registration, Censuses and the Work of the General Register Office, 1836–1952* (Hatfield, 2004).

3 Three examples of work on early childhood and infant mortality using the Registrar General's returns are: R. Woods and N. Shelton, *An Atlas of Victorian Mortality,* (Liverpool, 1997), Chapter 5; N. Williams and C. Galley, 'Urban–rural differentials in infant mortality in Victorian England', *Population Studies,* 49 (1995), pp. 401–20, https://doi.org/10.1080/0032472031000148746; and H. Jaadla and A.M. Reid, 'The geography

As the registration system evolved and public health focuses changed—often according to political and medical pressures—the Registrar General's returns themselves changed. An example is when, in 1875, infant mortality began to be reported as an explicit demographic rate: the number of infant deaths per 1,000 live births, known as the infant mortality rate (IMR).[4] Previously, mortality rates had been reported for all ages combined, sub-divided by gender, and occasionally by cause or by arbitrary age categories, but never consistently. David Armstrong argues that the creation of a specific mortality rate for infants signified the emergence of a medical interest, as well as the 'social recognition of the infant as a discrete entity'.[5]

Another important change to the Registrar General's returns was the shift to more precise information being given on death certificates from 1911. This included the reporting of place of residence and therefore enabled deaths to be redistributed across RSD boundaries.[6] Prior to 1911 there was a systematic official failure to redistribute public institutional deaths back to the usual place of residence, leading to distorted mortality statistics.[7] This distortion produced deflated mortality in RSDs where there were no or few institutions, and increased mortality where institutional populations were concentrated, as institutions were 'located at the end of a long and often winding road for the sick, and particularly the poor'.[8] We can refer to such movements as patient migration, whereby people would often cross RSD boundaries to reach an institution for help or treatment. Previous work has focused on all-age mortality and the distorting effect that institutions have on geographical patterns.[9] The distortion of infant mortality patterns, however, has been harder to get a handle on, as only specific types of institution affected this demographic measure. In particular, workhouses and maternity homes—including homes for unmarried mothers—would have been influential. Workhouses generally offered relief to single women, especially those with illegitimate infants who were at higher risk of

of early childhood mortality in England and Wales, 1881–1911', *Demographic Research*, 37 (2017), pp. 1,861–90, https://doi.org/10.4054/DemRes.2017.37.58.

4 The report for the year 1875 was published in 1877. For further discussion of the introduction of infant mortality to the Registrar General's reports, see C. Galley, 'Infant mortality in England, 1538–2000: trends, methods and sources', *Local Population Studies*, 102 (2019), pp. 21–52, here at pp. 35–6, https://doi.org/10.35488/lps102.2019.21.

5 D. Armstrong, 'The invention of infant mortality', *Sociology of Health and Illness*, 8 (1986), pp. 211–32, here at p. 212, https://doi.org/10.1111/j.1467–9566.1986.tb00298.x.

6 E. Higgs, ' The statistical Big Bang of 1911: ideology, technological innovation and the production of medical statistics', *Social History of Medicine*, 9 (1996), pp. 409–26, https://doi.org/10.1093/shm/9.3.409.

7 B. Luckin, 'Death and survival in the city: approaches to the history of disease', *Urban History Yearbook*, 7 (1980), pp. 53–62, here at p. 55, https://www.jstor.org/stable/44609199.

8 G. Mooney, B. Luckin and A. Tanner, 'Patient pathways: solving the problem of institutional mortality in London during the later nineteenth century', *Social History of Medicine*, 12 (1999), pp. 227–69, here at p. 231, https://doi.org/10.1093/shm/12.2.227.

9 Mooney *et al.*, 'Patient pathways'; A. Hardy, 'Death is the end of all disease: using the GRO cause of death statistics for 1837–1920', *Social History of Medicine*, 7 (1994), pp. 472–92, here at pp. 481–2, https://doi.org/10.1093/shm/7.3.472; B. Luckin, 'Evaluating the sanitary revolution: typhus and typhoid in London, 1851–1900', in R. Woods and Woodward (eds) *Urban Disease and Mortality in Nineteenth-Century England* (London, 1984), pp. 102-19, here at pp. 118–9.

mortality.[10] Additionally, a select number of hospitals that catered for infants were also responsible for inflating IMRs.[11] Urban areas tended to be particularly prone to such mortality distortions, as Naomi Williams and Graham Mooney found in their research on infant mortality in London and English provincial cities, 1840–1910.[12] It is therefore of utmost importance to consider institutions when studying infant mortality in historical London, a city made up of a 'mosaic of communities' with varied health outcomes.[13]

Previous work has attempted to tackle the accuracy of the Registrar General's mortality rates by combining RSDs into groups to reduce the number of deaths needing to be transferred between larger spatial units, redistributing deaths using surviving institutional records, or excluding districts where institutional deaths dominated.[14] This paper focuses on infant mortality—less studied than all-age mortality—and assesses whether more accurate IMRs for the resident populations could be attained from two alternative sources. The first source is the 1911 census of England and Wales, from which IMRs have been indirectly estimated.[15] The second is the collection of Medical Officer of Health (hereafter MOH) reports which provided a detailed and more nuanced breakdown of aggregate demographic rates, often with an attempt to redistribute institutional deaths.[16] Through the triangulation of these three sources, the differing IMR trends have been compared for the 15 years leading up to 1911. The findings highlight the inaccuracies of the Registrar General's figures in areas where institutions are concentrated, the importance of the information provided by the MOH reports in such areas, as well as demonstrating the value and accuracy of indirect estimation techniques using the 1911 census.

Geographical units

Perpetual challenges for historical demographers are the frequent, and often complicated, changes to administrative boundaries, and therefore the lack of consistent

10 Two examples of the high proportions of single women and illegitimate children in workhouses are discussed in A. Hinde and F. Turnbull, 'The populations of two Hampshire workhouses, 1851–1861', *Local Population Studies*, 61 (1998), pp. 38–53, here at p. 49.

11 The majority of hospitals at this time did not cater for infants. The select number of key London hospitals referred to here are listed in N. Williams and G. Mooney, 'Infant mortality in an 'Age of Great Cities': London and the English provincial cities compared, c. 1840–1910', *Continuity and Change*, 9 (1994), pp. 185–212, here at p. 190, https://doi.org/10.1017/S0268416000002265.

12 Williams and Mooney, 'Infant mortality'.

13 L. Marks, *Metropolitan Maternity: Maternal and Infant Welfare Services in Early Twentieth Century London* (Amsterdam, 1996), p. 1.

14 For combining RSDs, see G. Mooney, 'Did London pass the "sanitary test"? Seasonal infant mortality in London, 1870–1914', *Journal of Historical Geography*, 20 (1994), pp. 158–74, here at p. 159, https://doi.org/10.1006/jhge.1994.1013. For redistributing deaths, see Mooney *et al.*, 'Patient pathways', p. 230. For excluding districts where institutional mortality was too high, see Williams and Mooney, 'Infant mortality', p. 190.

15 The main database for the 1911 census derives from K. Schürer, E. Higgs, A.M. Reid and E.M. Garrett, *Integrated Census Microdata, 1851–1911, version V.2 (I-CeM.2)*, (2016) [data collection]. Colchester, England: UK Data Archive [distributor], SN 7481 [hereafter, 'I-CeM.2'].

16 The MOH Reports for London are digitised and available at the Wellcome Library, *London's Pulse: Medical Officer of Health Reports 1848–1972*, https://wellcomelibrary.org/moh/ [accessed 8 December 2020].

areal units over time.[17] For a city such as London, with a complex governance structure, this issue is only exacerbated.[18] It is therefore imperative that this is addressed from the outset.

The Registrar General's returns reported infant mortality by RSD—the finest spatial scale used for published vital statistics at the beginning of the twentieth century. In 1911, the geographical area of London consisted of 100 RSDs. These RSDs, however, were subject to boundary changes and amalgamations over time. For London, this often consisted of RSDs combining to create larger areas and thus fewer RSDs overall.[19] The amalgamation of RSD areas means that their demographic data can also be aggregated. It is worth noting however, that minor boundary shifts did occur concurrently, resulting in small but perhaps geographically important changes in the areas covered. The 1911 census also used the 100 RSD boundaries. Therefore, the individual-level data available from this source can be aggregated to the same geographical units used in the Registrar General's returns.[20]

In contrast, the MOHs were organised to oversee different administrative areas; areas which changed during the study time period due to the London Government Act of 1899. Prior to the Act, the areas covered by the MOHs consisted of 'twenty-nine administrative vestries (exclusive of the Local Board of Health of Woolwich) and thirteen district boards of works', within which there were numerous parishes and sub-districts.[21] After the Act of 1899, 28 districts were created and termed Borough Councils. Various powers were therefore transferred from the London County Council to the Borough Councils and the Metropolitan Borough areas were established.[22] Each administrative vestry, district board of works—and later metropolitan borough—produced their own annual MOH report. Within such reports, the areas were geographically disaggregated further into parishes, wards or sub-districts.

In the majority of cases, these smaller spatial units are directly comparable to the RSDs used by the Registrar General and the 1911 census. The MOH reports provide written and/or cartographical clarifications of the areas they are referring to, often explicitly setting

17 Williams and Mooney, 'Infant mortality', p. 188.

18 Further detail on the complex governance structure of London can be found in R. Porter, *London: a Social History* (London, 1994); and A. Saint, *Politics and People of London: London County Council, 1889–1965* (London, 1989).

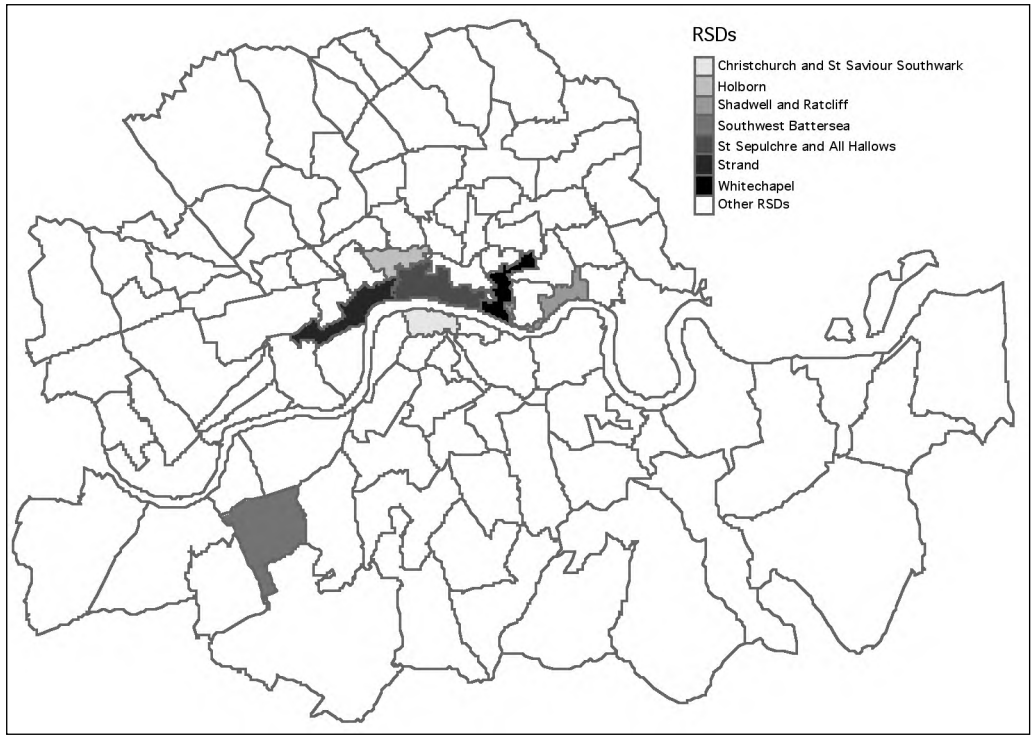
19 The number of London RSDs was derived from various Registrar General's *Quarterly Returns*. In 1891 there were 128 RSDs, in 1901 there were 114, and in 1911 there were 100. Interactive maps showing the RSD infant mortality rates for different census years can be found at A.M. Reid, S.J. Arulanantham, J.D. Day, E.M. Garrett, H. Jaadla and M. Lucas-Smith. 2018. *Populations Past: Atlas of Victorian and Edwardian Population* [2018] https://www.populationspast.org/ [accessed 8 December 2020].

20 The 1911 census data were obtained from the Integrated Census Microdata project: see https://icem.data-archive.ac.uk/ [accessed 8 December 2020].

21 A.C. Elliman, *Board of Works for the St. Saviour's District. Report of the Proceedings of the Board for the year 1899–1900,* p. 13 (available from Wellcome Library, *London's Pulse*).

22 The Registrar General's returns adopted these Metropolitan Boroughs for reporting, but not until 1912. Further information on the Metropolitan Boroughs and governing powers can be found in J. Seymour, M. Gorsky and S. Hajat, 'Health, wealth and party in inter-war London', *Urban History*, 44 (2017), pp. 464–91, https://doi.org/10.1017/S0963926816000377.

Figure 1 **Map of London, 1911, with the seven registration sub-districts (RSDs) of interest highlighted**



Source: Base map, J.D. Day, *Registration Sub-District Boundaries for England and Wales 1851–1911*. (Cambridge, 2016).

out how they compare to the RSDs. They do not, however, do this in a consistent way. For example: in the 1905 Report for Kensington, an 'Area of the Borough' section gives written descriptions of all the areas (RSDs, wards and Parliamentary Divisions) referred to in the Report, the 1907 Report for Paddington provides a tabulated list of which wards fall into each RSD, and the 1904 Report for Southwark includes a map of death rates for the wards of this Metropolitan Borough.[23] Each of these three reports confirms that the RSDs and the small areas used in the MOH Reports are geographically comparable, but in different ways. It is therefore important to emphasise here that there is not a hard and fast rule for checking the comparability of areas used in the sources; instead each MOH Report must be taken on a case-by-case basis.

23 T. Orme Dudfield, *The Annual Report on the Health, Sanitary Condition, etc., etc., of the Royal Borough of Kensington for the Year 1905*, p. 5; R. Dudfield, *Metropolitan Borough of Paddington. Annual Report of the Council for the Year 1907. Report of the Medical Officer of Health*, p. 1; G. Millson, *Borough of Southwark. Annual Report of the Medical Officer of Health, for the Year 1904*, p. 16. All three of these reports are available at Wellcome Library, *London's Pulse*.

This paper focuses on seven RSDs, selected for their suspected inflated IMRs reported by the Registrar General.[24] The seven RSDs are as follows: Christchurch and St Saviour Southwark, Holborn, Shadwell and Ratcliff, South West Battersea, St Sepulchre and All Hallows, Strand, and Whitechapel. Figure 1 shows them identified on a map of London. The majority of the RSDs are located in central London, bordering the River Thames. However, South West Battersea sits on the outskirts of the capital. Of these RSDs, six were geographically comparable to the areas in the MOH reports for the whole time period (1896–1911). One of them—Shadwell and Ratcliff—was only comparable until 1899. This will be examined later in a section which discusses Shadwell and Ratcliff in detail.

Sources and methods

To tackle the concerns regarding the accuracy of the Registrar General's infant mortality figures, a method of triangulation has been employed to compare and contrast infant mortality rates (IMRs) from three separate sources: (1) the Registrar General's returns; (2) the 1911 Census and (3) the MOH Reports. The Registrar General's returns and the 1911 Census were used for all 100 London RSDs. The MOH reports, however, were only used for seven RSDs, due to the focus on RSDs with seemingly inflated IMRs and the time-consuming nature of data collection from this source. All three sources and the methods used to collect or calculate the IMRs will be discussed in detail in this section.

Registrar General's returns

The Registrar General's *Weekly, Quarterly* and *Annual Returns* form the 'bedrock' of much of the historical demography of England and Wales from 1837.[25] These returns reported aggregated data on mortality and morbidity and published it in the public domain, removing issues of access that may be present for other sources, whether that be the privacy laws surrounding census data or the limited copies of specific MOH reports. For this paper, the Registrar General's *Quarterly Returns* have been used to collate annual IMRs for each RSD in London from 1896 to 1911. Infant mortality was expressed as an explicit demographic rate, but the returns also reported the absolute numbers of births and infant deaths registered in each RSD.

Despite the convenience of the Registrar General's returns, and the large volume of data available over space and time, there are concerns over this source's accuracy for geographical units with smaller populations before 1911.[26] One particular influence on the IMR within an area was the presence of public institutions, such as hospitals. This could

24 The suspected inflated IMRs were identified through having the most discordant Registrar General's reported IMRs and indirect estimates calculated from the 1911 census (when compared to all RSDs).

25 M. Smallman-Raynor and A. D. Cliff, *Atlas of Epidemic Britain: a Twentieth Century Picture* (Oxford, 2012), p. 5.

26 Concerns over the accuracy of the Registrar General's returns are developed in B. Luckin, 'Death and survival', pp. 53–62; and A. Hardy, 'Death is the end of all disease', pp. 481–2.

result in patients migrating from another RSD and, if they died, inflating mortality figures.[27] Two extreme examples of the influence of institutions on mortality rates are the Strand and London City registration districts, where in 1901 63 per cent and 66 per cent of deaths at all ages respectively were in hospitals, workhouses or other institutions.[28] For infant mortality, the most influential institutions were larger hospitals (and specifically lying-in hospitals), as well as workhouses and maternity homes. Whilst a significant number of additional births were not likely to be recorded in these institutions, they did increase the number of infant deaths as sick and vulnerable infants were brought into them.[29] The distortion in the IMRs created by the presence of institutions and patient migration can have a large effect on comparisons and the results of statistical analyses.[30]

Indirect estimation using the 1911 Census

The 1911 census of England and Wales included a series of questions designed to gather information on the 'fertility of marriage', thereby providing a rich data source for analysing married couples' fertility and early-age mortality experiences in the early twentieth century.[31] Using the answers to these questions, indirect estimates of infant mortality trends over time have been constructed for the whole of London and separately for London's 100 RSDs.

Conventional measures of mortality require numbers of deaths classified by age (and sometimes cause), and the number of people alive in each age group or, for infant mortality, the number of live births. Unfortunately, such data are often not available in low- and middle-income countries, nor in historical contexts. William Brass developed a suite of indirect estimation techniques to be used in such situations, one of which produced estimates of early age mortality from information given by women on the numbers of children born and still alive.[32] Ansley Coale and James Trussell, and later Griffith Feeney,

27 E, Higgs, 'Statistical Big Bang', p. 423; P. Ward, *Birth Weight and Economic Growth* (Chicago, 1993); Mooney *et al*., 'Patient pathways'.

28 Williams and Mooney, 'Infant mortality', pp. 188–9.

29 The vast majority of births in England at the start of the twentieth century took place at home and were reported as such. Therefore, institutions were not likely to report a considerable number of additional births, see A.M. Reid. 'Birth attendants and midwifery practice in early twentieth-century Derbyshire', *Social History of Medicine*, 25 (2012), pp. 380–99, here at p. 384, https://doi.org/10.1093/shm/hkr138.

30 For discussion of the same issue, see C. Galley, 'Infant mortality in England, 1538–2000: stability and the beginnings of change, 1837–1910', *Local Population Studies*, 106 (2021), pp. 98–209, here at pp. 111–12, https://doi.org/10.35488/lps106.2021.98.

31 Questions were specific to the present marriage and included: the number of completed years the marriage had lasted, the total number of children born alive, the number of children still living, and the number of children who had died. For a figure showing how these questions were presented in the census schedule, see E.M. Garrett, A.M. Reid, K. Schürer and S. Szreter. *Changing Family Size in England and Wales. Place, Class and Demography, 1891–1911* (Cambridge, 2001), p. 6.

32 W. Brass, *Methods for Estimating Fertility and Mortality from Limited and Defective Data* (Chapel Hill, 1975); United Nations, *Manual X: Indirect Techniques for Demographic Estimation* (New York, 1983).

then extended this technique to estimate time trends in infant mortality.[33] It is the Trussell version of the Brass method that has been used in this paper, as was also effectively employed by Eilidh Garrett and her colleagues.[34] Although this indirect estimation method is not straightforward, there are a number of detailed step-by-step guides available, along with worked examples.[35] The method will also be outlined here.

The indirect estimation of time trends in infant mortality requires women to be grouped by marital status and marital duration. For each marital duration group the following information is needed: first, the number of women in the group; second, the number of their children ever born inside their current marriage; and, third, the number of those children who had died.[36] The Report on the Fertility Census of England and Wales produced extensive tabulations of these figures for a number of aggregated groups—such as social class—which have been used in previous work.[37] It is also possible to calculate these figures for other sub-populations of England and Wales, as long as the population can be defined by data provided in the census.

The first step is to calculate for each five-year marital duration group the proportions dead among children ever born by dividing the total number of dead children by the total number of children ever born.[38] Multipliers are then applied to these proportions to estimate the probability of children dying by a given exact age, denoted $q(x)$.[39] The marital

33 A.J. Coale and J. Trussell, 'Estimating the time to which Brass estimates apply,' Annex I to S.H. Preston and A. Palloni 'Fine-tuning Brass-type mortality estimates with data on ages of surviving children', *Population Bulletin of the United Nations*, 10 (1978), pp. 87–9; G. Feeney, 'Estimating infant mortality trends from child survivorship data', *Population Studies*, 34 (1980), pp. 109–28, https://doi.org/10.1080/00324728.1980.10412839.

34 The method is described in detail in Appendix A of Garrett *et al., Changing Family Size,* pp. 441–67.

35 For detailed step-by-step guides on the indirect estimation of child and infant mortality using the Trussell version of the Brass Method, see: United Nations, *Step-by-Step Guide to the Estimation of Child Mortality* (New York, 1990), pp. 25–33; International Union for the Scientific Study of Population (IUSSP), *Indirect Estimation of Child Mortality* [2013], http://demographicestimation.iussp.org/content/indirect-estimation-child-mortality [accessed 8 December 2020].

36 In place of the marital duration groups of women, age groups can also be used. However, in situations such as historic Britain where women married relatively late, marital duration groups produce better results, as explained in J.M. Sullivan, 'Models for the estimation of the probability of dying between births and exact ages in early childhood', *Population Studies*, 26 (1972), pp. 79-97, here at p. 91, https://doi.org/10.1080/00324728.1972.10405204.

37 The figures for a limited number of aggregated groups are found in Census of England and Wales, 1911, *Vol. XIII: Fertility of Marriage Part II* (London, 1923). An example of the use of such figures in child mortality indirect estimation techniques is found in S. Preston and M. Haines, *Fatal Years: Child Mortality in Late Nineteenth Century America* (Princeton, 1991), pp. 179–80.

38 Couples were excluded from the indirect estimation calculations if: (1) they were marked as 'invalid'; (2) the children ever born value was greater than the number of years married plus two; and (3) the wife's age at marriage value was less than 10 or greater than 40 years. This was to remove any transcription errors in the I-CeM database. Couples whose relationship status was coded as 'married, but spouse not present in the household' were not excluded from the calculations, however. There are only a relatively small number of such couples, and after an investigation into a sample of them it was concluded that their data were valid.

39 The multipliers are calculated using coefficients based on the Coale-Demeny families of model life tables, as well as parity ratios. A model life table family is selected on the basis of how closely its early age mortality structure matches that of the population being studied. In this instance the 'West' family mortality

Table 1 Example of the application of the Trussell version of the Brass method to data from the 1911 census: the married population of London

Marital duration group (years)	Corresponding exact age	Proportion of children who have died	Estimated probability of dying by exact age x, $q(x)$	Reference time, $t(i)$	Reference date (1911.25 – $t(i)$)	Common index: IMR (per 1,000 live births)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0–4	2	0.091	0.104	1.351	1909.899	81.228
5–9	3	0.138	0.138	3.507	1907.743	100.080
10–14	5	0.177	0.179	6.026	1905.224	121.453
15–19	10	0.203	0.210	8.696	1902.550	131.763
20–24	15	0.226	0.228	11.652	1899.598	138.786
25–29	20	0.245	0.244	14.906	1896.344	140.326

Notes: Multipliers calculated from the Coale-Demeny West family mortality model coefficients and parity ratios. The assumed age structure of mortality used to calculate the common index (column (7)) was the 1910–1912 England and Wales life table.

Sources: Data from Census of England and Wales, 1911, *Vol. XIII: Fertility of Marriage Part II* London, 1923). For method, see E.M. Garrett, A.M. Reid, K. Schürer and S. Szreter. *Changing Family Size in England and Wales. Place, Class and Demography, 1891–1911* (Cambridge, 2001), pp. 441–67.

duration groups and the exact 'target' ages they correspond to can be seen in Table 1, columns 1 and 2. These exact ages are used in all Brass-type estimation procedures and are derived from the average age of the children of the women in each marital duration group.

The estimates of the probability of children dying by a given exact age can be combined to create a life table or used to measure the underlying trend in mortality. In this instance we are interested in the latter use and therefore employ two further steps to pinpoint the estimates in time, and then convert all estimates into a common index: IMR. The reference times (denoted as $t(i)$) are estimated for each $q(x)$. They are calculated using another set of coefficients from the Coale-Demeny West family mortality model and parity ratios.[40] The reference time is expressed in terms of the number of years before the census and can therefore be subtracted from the census date to give the actual date of the estimate. In this case, the census date is taken to be 1911.25, as the census was undertaken on 2 April 1911 and therefore a quarter of the way through the year.

Once each $q(x)$ has been assigned a reference time, the probabilities of dying before a given exact age need to be converted into IMRs. This is done using the Brass relational logit life table approach. The basic concept of this approach is that the estimates, in their current

model is most appropriate. For details on the calculation of the multipliers and for Coale-Demeny coefficients, see: United Nations, *Step-by-Step Guide*, pp. 25–6. For the Coale-Demeny model life tables, see A.J. Coale, P. Demeny and B. Vaughan, *Regional Model Life Tables and Stable Populations*, 2nd edn (Princeton, NJ, 1983).

40 For the full list of Coale-Demeny coefficients and the equation to calculate the reference times ($t(i)$), see: United Nations, *Step-by-Step Guide*, pp. 25–7.

form, can each be converted into the probability of dying before age one year, if they can be related to a suitable standard life table. Logit transformations are used so that the relationship between the estimates and the standard life table are on a linear scale and are thus easier to convert.[41] This method therefore requires the assumption of a particular age pattern of mortality by using a model life table. Here, as in the work of Eilidh Garrett and her colleagues, the 1910–1912 England and Wales life table has been used as a standard, as it is thought most likely to be representative of the age structure of mortality in London over our study time period (1896–1911).[42]

Table 1 shows the application of the Trussell version of the Brass indirect estimation method to the married population of London, as a whole, from the 1911 census. Unlike the figures in the Registrar General's returns, these indirect estimates of infant mortality exclude the distorting effect of institutions caused by patient migration across RSD boundaries, because they are calculated using births and child deaths of married women living in each RSD on census night. They are however, at risk of being distorted by population migration and/or by the exclusion of vulnerable populations from the calculations.

First, regarding population migration, the calculations assume that the population present in an area in 1911 was also the population in the past. This is unlikely to be entirely accurate, particularly in London, due to the fluidity of its population, as some families will have moved within the city, while others will have migrated into the capital from other parts of the country, or from abroad.[43] Consequently, women may be reporting their childhood mortality experience from a different physical environment, despite currently residing in a particular London RSD. This distorting effect is likely to increase as the calculations go further back in time.

Second, the indirect estimation method only considers data from married couples and excludes groups which are more vulnerable to child mortality. Such groups include those who were destitute on the night of the census, widows and widowers who were not coded

41 For more detail on the Brass relational logit life table approach, including the formulas for logit transformations, conversion of each $q(x)$ to the probability of dying before age one year and the anti-logit, see International Union for the Scientific Study of Population, *Relational Model Life Tables*, https://papp.iussp.org/sessions/papp103_s01/PAPP103_s01_110_010.html [accessed 9 December 2020]; C.J.L. Murray, B.D. Ferguson, A.D. Lopez, M. Guillot, J.A. Salomon and O. Ahmad, 'Modified logit life table system: principles, empirical validation and application', *Population Studies*, 57 (2003), pp. 165–82, here at pp. 167–9, https://doi.org/10.1080/0032472032000097083.

42 Note that we assume that the age pattern of mortality was extant for the full study time period, although the level of mortality may in fact have changed. The 1910–1912 England and Wales life table and its application to this method specifically can be seen in Garrett *et al.*, *Changing Family Size*, p. 448.

43 This is discussed in detail in K. Schurer and J. Day, 'Migration to London and the development of the north–south divide, 1851–1911', *Social History*, 44 (2019), pp. 26–56, https://doi.org/10.1080/03071022.2019.1545361. Particular reference to the importance of family migration can be found here at pp. 41–2. For estimates of population mobility in a ten-year intercensal period at this time, and some of the effects on infant mortality as calculated using indirect estimation, see A.M. Reid, E.M. Garrett and S. Szreter, 'Residential mobility and child mortality in early twentieth century Belfast', in D. Ramiro Fariñas and M. Oris (eds), *New Approaches to Death in Cities during the Health Transition* (Cham, 2016), pp. 55–76.

as married, and single parents listed with their illegitimate offspring. These exclusions lead to an expected, but marginal, underestimation of calculated IMRs using this method. For example, it is well documented that infant mortality amongst illegitimate children was much higher than amongst legitimate children, until the 1950s,[44] and in England and Wales in 1907, urban illegitimate infants were 2.1 times more likely to die than legitimates.[45] The exclusion of these groups of particularly vulnerable infants—who were more 'at risk' from dying—has the potential to decrease the IMR estimate of each RSD, although only by a small amount due to the relatively low numbers of illegitimate births.

Medical Officer of Health reports

Medical Officer of Health (MOH) reports were produced annually from 1848 to 1972 by the MOH of each district to provide statistical data about births, deaths and diseases, as well as comments on the health of the population. Over time, the MOHs dealt with an increasingly broad range of topics in their reports as the work of public health departments expanded, resulting in very rich archival sources.[46] The information supplied in each of the MOH reports varied according to the author(s) and their interests and preferences; the work of some MOHs has been deemed energetic and innovative, whereas others only provided what was considered the standard report.[47] The individualistic nature of such reports complicates comparative work, across both time and space. However, information regarding illegitimate infant mortality, public institutions and RSD-specific circumstances published in the MOH reports can provide invaluable insights for unpacking IMRs. Crucially, there were attempts to redistribute institutional deaths of non-residents, the very deaths that were likely to distort the Registrar General's IMRs.[48]

For London, these reports have been digitised by the Wellcome Library and therefore can be searched using keywords.[49] Despite the ease of the search feature, piecing together information from the MOH reports proved to be a time-consuming task. This was, in part, due to the differences in geographical units and the boundary changes of the London Government Act (1899) which meant that the areas covered by the MOHs were not always

44 The link between illegitimacy and higher infant mortality was reported during the study time period in His Majesty's Stationery Office, *Report of the Inter-Departmental Committee on Physical Deterioration*, Vol. 1 (London, 1904), p. 44. For further, more contemporary, examples of work that have shown this link, see A. Davin, 'Imperialism and motherhood', *History Workshop Journal*, 5 (1978), pp. 9–65, here at p. 28, https://doi.org/10.1093/hwj/5.1.9; Marks, *Metropolitan Maternity*, pp. 103–5; A.M. Reid, ' Infant feeding and child health and survival in Derbyshire in the early twentieth century', *Women's Studies International Forum*, 60 (2017), pp. 111–9, here at p. 114, https://doi.org/10.1016/j.wsif.2016.10.011.

45 Registrar General, *Sixty-Ninth Annual Report of the Registrar General* (London, 1908), British Parliamentary Papers (hereafter BPP) 1908 XVII, p. cxxx.

46 For a brief overview of the MOH Reports, see Wellcome Library, *About the Reports* https://wellcomelibrary.org/moh/about-the-reports/about-the-medical-officer-of-health-reports/ [accessed 9 December 2020]. For an example of detailed use of the MOH reports in London see: A. Hardy, *The Epidemic Streets*: *Infectious Disease and the Rise of Preventive Medicine, 1856–1900* (Oxford, 1993).

47 Seymour *et al.*, 'Health, wealth and party', p. 468.

48 Higgs, 'The statistical Big Bang', pp. 423–4.

49 Wellcome Library, *London's Pulse*.

Table 2 **Summary of the geographical areas used in the search criteria and comments on relevant administrative changes**

1911 registration sub-district	1911 registration district	Geographical area used in search criteria	Comments
Christchurch and St Saviour Southwark	Southwark	Pre-1900: 'St Saviour's (Southwark) Post-1900: 'Southwark'	1899 London Government Act changed the administrative area that reported on this RSD
Holborn	Holborn	'Holborn'	Pre-1900 area refers to the areas of the St. Giles and Holborn District Board of Works. This area is marginally different to Holborn RSD, which was reported on post-1900
Shadwell and Ratcliff	Stepney	Pre-1900: 'Limehouse' Post-1900: 'Stepney'	Shadwell and Ratcliff proved difficult to locate in the MOH reports. The figures for the equivalent RSD area were only available pre-1900. Post-1900 it was not possible to match the administrative areas
South West Battersea	Wandsworth	'Battersea'	SW Battersea RSD was referred to specifically throughout the time period
Strand	Strand	Pre-1900: 'Strand (Westminster)' Post-1900: 'City of Westminster'	1899 London Government Act changed the administrative area that reported on this RSD
St Sepulchre and All Hallows	London City	'City of London'	From 1901 to 1905, explicit IMRs were not reported for this RSD
Whitechapel	Whitechapel	'Stepney'	Pre-1900 reported by the MOH for Whitechapel. Post-1900 reported by the MOH for Stepney. Whitechapel RSD referred to specifically

Sources: Medical Officer of Health reports for various London districts: available at Wellcome Library, *London's Pulse: Medical Officer of Health Reports 1848-1972*, https://wellcomelibrary.org/moh/ [accessed 8 December 2020].

coterminous with the RSDs. As a consequence, the seven RSDs with the most discordant Registrar General's reported IMRs and indirect estimates calculated from the 1911 census (when compared to all RSDs) were chosen to be investigated in detail within the scope of this paper.

The *London's Pulse* website enables an advanced search of the MOH reports. It is possible to enter keywords, select the location that you wish the reports to cover and select the time

period of interest. The advanced search criteria used in the investigation of the seven RSDs were as follows:

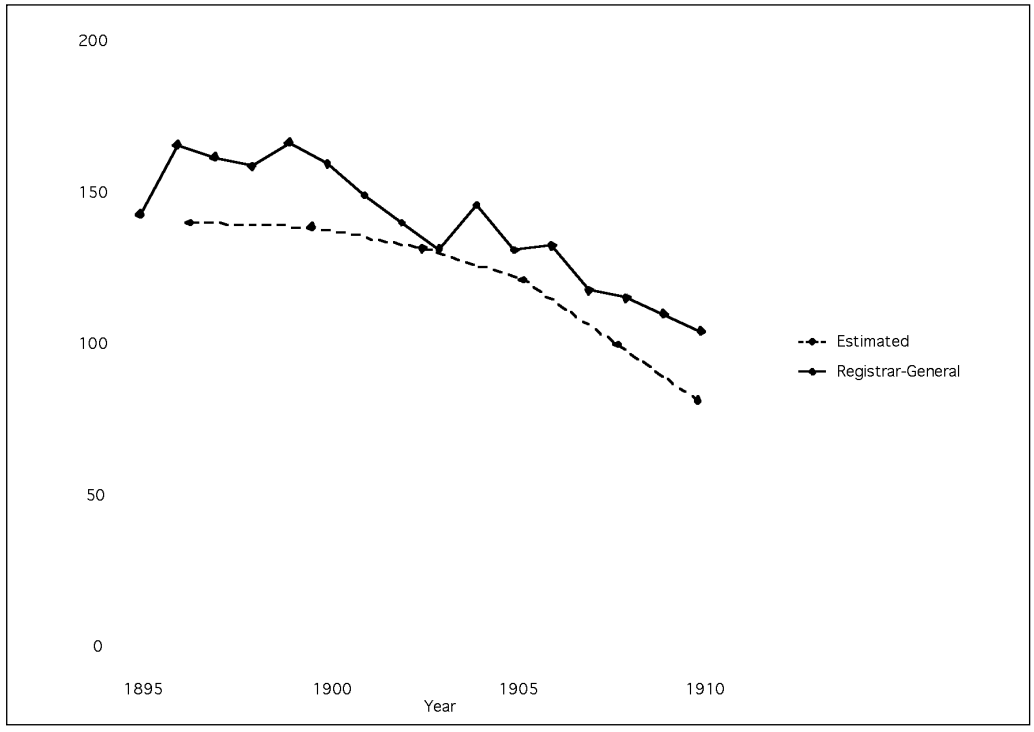
- search term: 'infant mortality' OR 'infantile mortality',
- location: the appropriate geographical area for each of the seven RSDs was chosen from the dropdown list (see Table 2 for details of this selection for each RSD of interest),
- time period: 1890–1911.

The results of the advanced search were then systematically reviewed, collating data on IMRs, geographical boundary information, key institutions and comments regarding illegitimate births and deaths.

Results

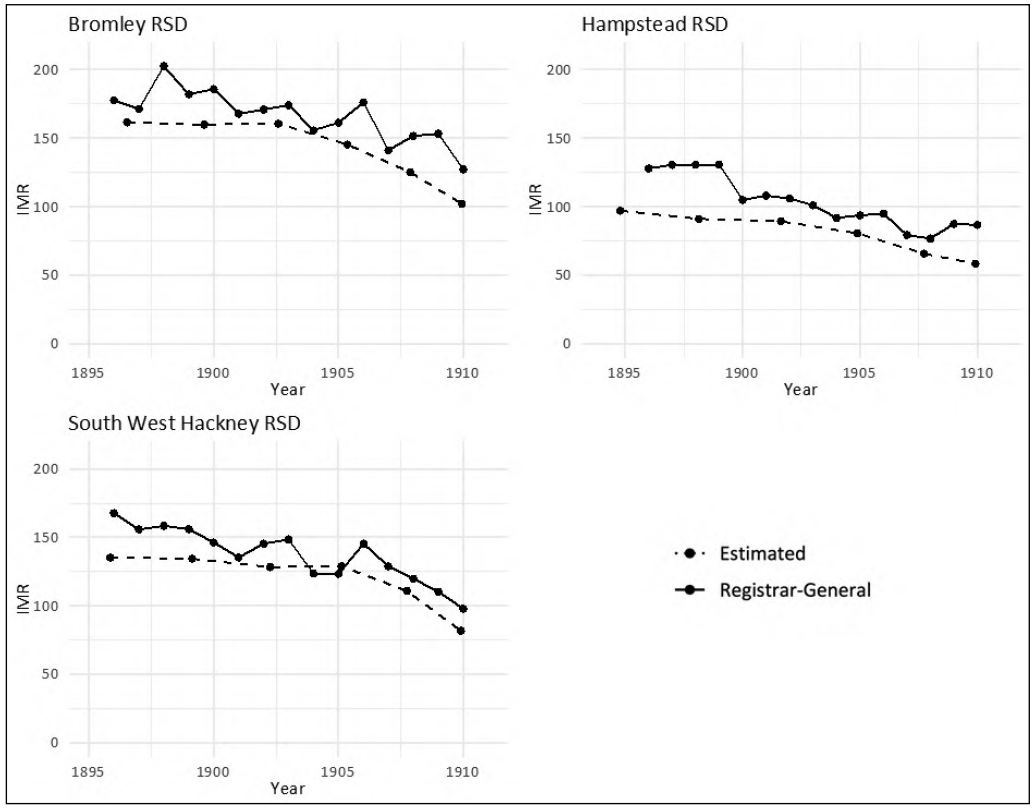
Figure 2 shows the indirect estimates of the infant mortality rate (IMR) for the whole of London, computed using the methods outlined above, as well as the IMR reported in the Registrar General's returns for the capital as a whole. The estimated trend should be

Figure 2 Registrar General's reported infant mortality rates and indirect estimates from the 1911 census for London, 1896–1910



Source: Registrar-General's *Quarterly Returns* and own calculations using data from Census of England and Wales, 1911, *Vol. XIII: Fertility of Marriage Part II* (London, 1923).

Figure 3 **Registrar General's reported infant mortality rates and indirect estimates from the 1911 census for three typical London registration sub-districts (RSDs), 1896–1910**

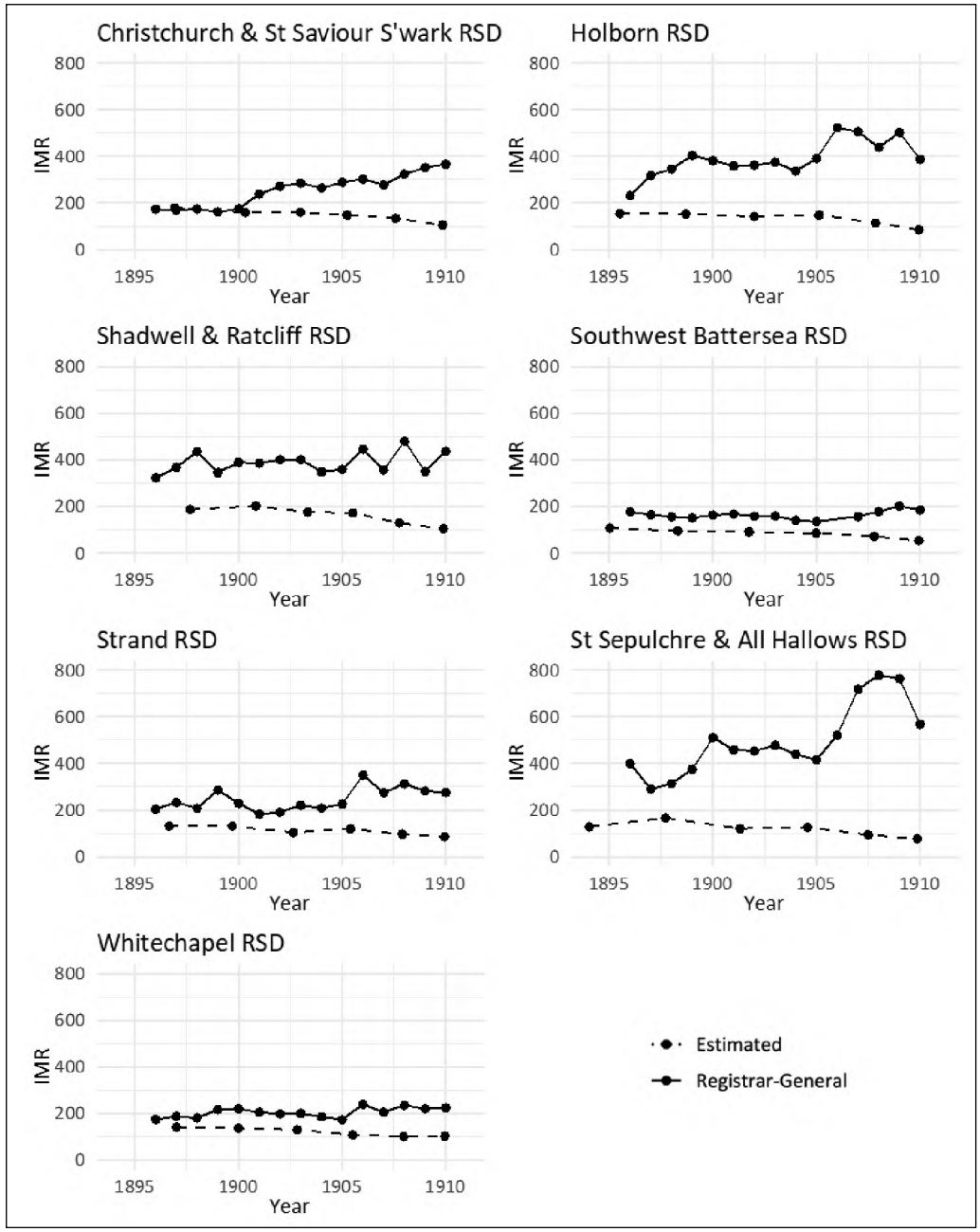


Sources: Registrar-General's *Quarterly Returns* and own calculations using data from Census of England and Wales, 1911, *Vol. XIII: Fertility of Marriage Part II* (London, 1923).

interpreted as a smoothed measure of infant mortality over time and therefore any short-term variations seen in the reported trend are not apparent. The general trend is, however, remarkably similar to the reported trend, providing further evidence that the estimation techniques used are robust. As discussed above, the computed IMR was expected slightly to underestimate the actual level of the IMR, and this is seen in Figure 2. Indirect estimates of infant mortality trends were also calculated for each London RSD. For the vast majority of RSDs, the indirect estimates were as expected when plotted against the Registrar General's IMRs (see Figure 3 for three examples of this: Bromley; Hampstead and South West Hackney RSDs).

However, the seven RSDs that constitute the focus of this paper were reported by the Registrar General to have considerably higher IMRs than the indirect estimates reconstructed. Additionally, the two series in each graph follow different time trends. These RSDs are shown in Figure 4 and are clearly puzzling: why were there seemingly such large discrepancies between the indirect estimates and the IMRs reported by the Registrar General? If population

Figure 4 **Registrar General's reported infant mortality rates and indirect estimates from the 1911 census for seven anomalous London registration sub-districts (RSDs), 1896–1910**



Note: The *y*-axis has been quadrupled in comparison to Figures 2–3, to ensure that the inflated rates reported by the Registrar General could be plotted.

Sources: Registrar General's *Quarterly Returns* and own calculations using data from Census of England and Wales, 1911, Vol. XIII: Fertility of Marriage Part II (London, 1923).

migration was causing the discrepancies seen, one would expect the indirect estimates and Registrar General's IMRs to be similar, close to the 1911 census, then diverge further back in time, as the population becomes less like the population present on the census night. This was not the pattern for any of the RSDs investigated.

The size of the differences between the IMR trends also suggest that they were unlikely to be caused by the exclusion of unmarried mothers within the indirect estimate calculations. Archival research undertaken on the MOH reports supported this conclusion. It very quickly became apparent that the influence of illegitimate infants was not significant due to the relatively low numbers recorded in each RSD. For example, in Christchurch and St Saviour Southwark in 1908, only 15 illegitimate births were recorded (compared to 548 legitimate births and 57 infant deaths).[50] In the same year, no illegitimate births were recorded in St Sepulchre and All Hallows.[51] In fact, the MOH of the Limehouse District—Daniel Lewis Thomas—noted that 'the number of [illegitimate] children thus born in this district is very low when compared with England and Wales … [t]he number of illegitimate children is very much larger in agricultural than in industrial districts'.[52] Admittedly, we must consider here that the number of reported illegitimate children does not necessarily equate to the true number of illegitimates, as no proof was needed to show that a mother was genuinely married to the man she said was the father of their child. This sort of deception would have been easier to achieve in an urban area, where you were likely to be unknown to the registrar recording your child's birth. Regardless, with such low reported illegitimate births (and therefore infant deaths) in the RSDs of interest, this cannot have been the main influence on the inflated mortality rates seen in the Registrar General's returns.

A common theme that did emerge from the investigation of the MOH reports was the influence that institutions had on mortality rates. Contrary to the Registrar General, the MOHs appear to have been redistributing institutional deaths to their place of residence, or, at least, removing those that were not resident in their RSD from their reported figures. The MOHs had access to information from their own institutions which enabled them to distinguish the deaths of people who were resident in their RSDs from the deaths of non-residents. They did not however, have access to the numbers of citizens from their district who died in institutions elsewhere. The MOH of the City of London states that 'slight discrepancies will be observed, due to the fact that I have not been furnished with the number of citizens who died in Institutions other than those with which the City is connected'.[53] As a consequence of this, the IMRs 'corrected' by the MOHs may be

50 G.B. Millson, *Borough of Southwark. Annual Report of the Medical Officer of Health for the Year 1908*, p. 42 (available at Wellcome Library, *London's Pulse*).

51 W.M. Collingridge, *Report of the Medical Officer of Health for the City of London for the Year 1908,* p. 17 (available at Wellcome Library, *London's Pulse*).

52 Limehouse would certainly have been deemed an industrial district, even when compared to other London districts, due to its proximity to the London dockyards, see: D.L. Thomas, *Report on the Sanitary Condition of the Limehouse District, for the Year 1898,* p. 24 (available at Wellcome Library, *London's Pulse*).

53 W.S. Saunders, *Report on the Sanitary Condition of the City of London for the Year 1897*, p. 10 (available at Wellcome Library, *London's Pulse*).

marginally lower than the true infant mortality of the population, yet still more realistic than the inflated rates recorded in the Registrar General's returns.

Figure 5 shows the MOH's IMR trends, for Christchurch and St Saviour Southwark, Holborn, South West Battersea, Strand, St Sepulchre and All Hallows, and Whitechapel.[54] As we can see, once the non-resident infant deaths were removed, the IMRs lowered to remarkably similar levels and time trends to those that were indirectly estimated from the 1911 census. Whitechapel RSD and South West Battersea RSD had the most complete infant mortality records in the MOH reports, consistently redistributing non-resident infant deaths and uncomplicated by significant boundary changes. The Battersea MOH highlighted the hospital and two workhouses present in South West Battersea RSD that would have been distorting the IMRs reported by the Registrar General.[55] For Whitechapel, the London Hospital and Whitechapel Infirmary were identified as inflating the number of infant deaths in this RSD. For example, in 1898, 98 non-resident infant deaths were recorded in the Whitechapel district. For the same year, resident infant deaths were only 278.[56] The inclusion (or exclusion) of the non-resident deaths when calculating the IMR means a difference of 49 infant deaths per 1,000 live births which explains the discrepancy between the Registrar General's rate of 187 per thousand and the MOH's rate of 138.[57] The latter of these rates is more in line with the indirect estimate. Similar non-resident infant death figures are reported throughout the time period, the majority of these being in the London Hospital, with a lesser, but not insignificant, number reported in the Whitechapel Infirmary.[58]

St Sepulchre and All Hallows RSD suffered from inconsistent reporting of the IMR, or at least redistributed infant deaths, across the full time period. However, the data that were available from the MOH reports did coincide with the level and time trend of infant mortality produced by the indirect estimates. Again, the prominent role of institutions in inflating IMR through non-residents was clear. St Bartholomew's Hospital was situated in St Sepulchre and All Hallows RSD, and consistently reported a relatively large number of infant deaths: 51, 74 and 67 in 1894, 1895 and 1896 respectively, for example.[59] The

54 Note that adequate data could not be collected for the Shadwell and Ratcliff RSD due to administrative boundary changes. This will be discussed further in the special discussion of Shadwell and Ratcliff section.

55 G.F. McCleary, *Report on the Health of the Metropolitan Borough of Battersea for the Year 1904*, p. 19 (available at Wellcome Library, *London's Pulse*).

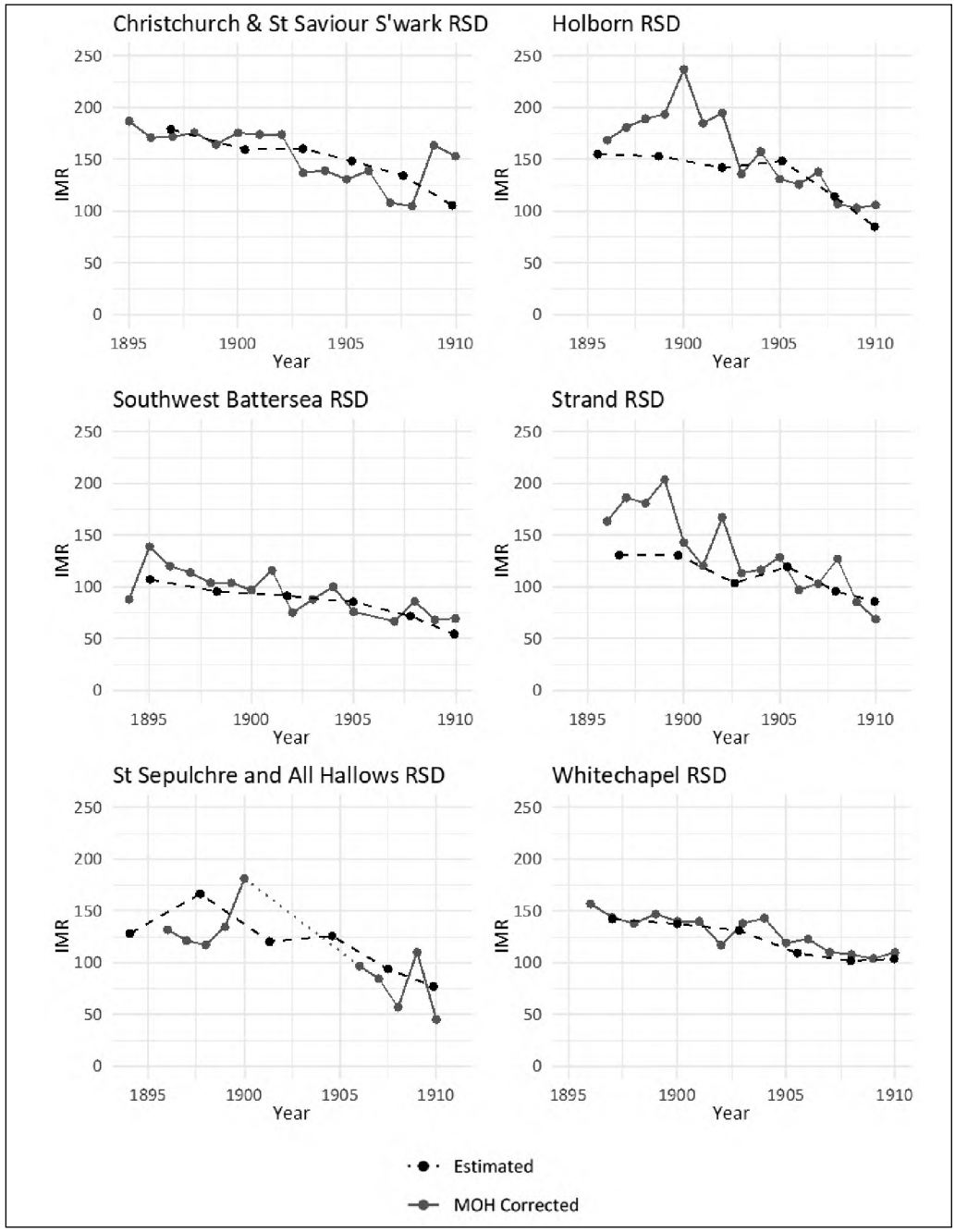
56 J. Loane, *Annual Report on the Sanitary Condition of the Whitechapel District, with vital and other statistics, for the Year 1898*, pp. 16–8 (available at Wellcome Library, *London's Pulse*).

57 These IMRs were both calculated using the same denominator of 2,014—the number of births registered in the Whitechapel district for the year 1898. Institutional births were not redistributed at this time, as the redistribution of population denominators was more complex than the redistribution of deaths to place of residence.

58 An example of a report recording non-resident infant deaths in these institutions is Loane, *Annual Report on the Sanitary Condition of the Whitechapel District*.

59 W.S. Saunders, *Report on the Sanitary Condition of the City of London for the Year 1894*, p. 13; W.S. Saunders, *Report on the Sanitary Condition of the City of London for the Year 1895*, p. 8; W.S. Saunders, *Report on the Sanitary Condition of the City of London for the Year 1896*, p. 10 (all available at Wellcome Library, *London's Pulse*).

Figure 5 **'Corrected' Medical Officer of Health (MOH) infant mortality rates and indirect estimates from the 1911 census for six anomalous London registration sub-districts (RSDs), 1896–1910**



Sources: Own calculations using data from Census of England and Wales, 1911, *Vol. XIII: Fertility of Marriage Part II* (London, 1923); Medical Officer of Health Reports available at Wellcome Library, *London's Pulse: Medical Officer of Health Reports 1848–1972*, https://wellcomelibrary.org/moh/ [accessed 8 December 2020].

majority of these deaths were of infants from outside the RSD. Other institutional mortality that was reported in St Sepulchre and All Hallows RSD included deaths in the City Police Hospital and the Royal London Ophthalmic Hospital. These hospitals, along with many others at the time, rarely recorded infant deaths due to the hospitals' smaller sizes and their lack of ability to cater for young patients.[60]

Christchurch and St Saviour Southwark RSD had endured an inflated IMR from 1900 onwards according to the Registrar General's returns (see Figure 4). Prior to 1900 the IMRs reported by the MOH and the Registrar General were practically identical (perhaps differing by one or two births and/or infant deaths each year). In 1899 however, the London Government Act introduced many considerable administrative boundary changes that affected the MOH areas. For Christchurch and St Saviour Southwark this meant that 'the Parishes of St. Saviour, Christchurch, St. George-the-Martyr, and St. Mary, Newington, [were] grouped to form one of the Borough Councils under the new administration' which was named the Borough of Southwark.[61] The boundary alterations were recorded and shown on a map within the MOH Report; and they led to 'the whole of Guy's Hospital [being] included in the new Borough of Southwark'.[62] Specifically, Guy's Hospital fell into the jurisdiction of St Saviour RSD (later the combined RSD Christchurch and St Saviour Southwark), having previously been in the St Olave Registration District (later Bermondsey Registration District).[63]

These administrative changes and boundary alterations took effect in 1900, when non-resident infant deaths in Guy's Hospital began to be included in the IMR reported by the Registrar General for St Saviour. Reference to the 'corrected' numbers of deaths through redistributing non-residents in public institutions was mentioned consistently from 1901 to 1910 in the MOH reports covering Christchurch and St Saviour Southwark.[64] Although the 'corrected' IMRs for this RSD are not as similar to the indirect estimates, as was the case in other RSDs, they are still more realistic than the Registrar General's figures.

Holborn was a particularly difficult RSD to track across the time period, again due to the London Government Act of 1899, and therefore the changes in the administrative area for which infant mortality was reported. Prior to 1900, the MOH reports covered the Holborn Board of Works administrative area, which was not coterminous with the area the Registrar General defined as Holborn. In 1896 for example, the MOH states that 'there are many anomalies with regard to parts of "Holborn" ', including the inclusion of

60 An example of these institutions and their lack of infant deaths can be found in Sedgwick Saunders, *Report on the Sanitary Condition of the City of London for the Year 1894*.

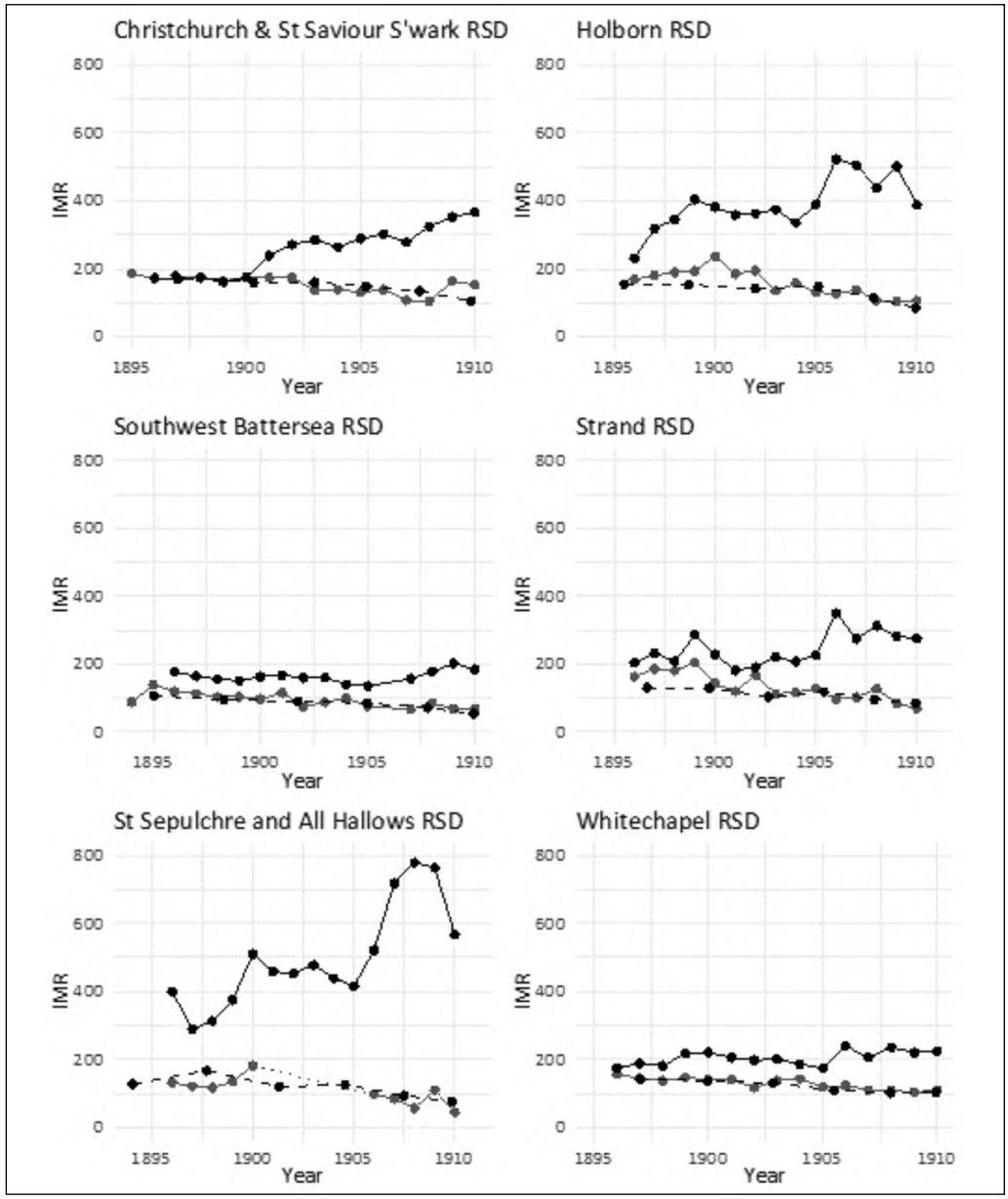
61 Elliman, *Board of Works for the St. Saviour's District*, p. 13.

62 Elliman, *Board of Works for the St. Saviour's District*, p. 17.

63 An example of Guy's Hospital being mentioned as part of the Registration District of St. Olave prior to the London Government Act of 1899 is W.A. Bond, *The Board of Works for the St. Olave District. Annual Report of the Sanitary Condition of the District for the year 1895*, p. 4 (available from Wellcome Library, *London's Pulse*).

64 An example of the use of the term 'corrected' numbers of deaths can be found in G.B. Millson, *Borough of Southwark. Annual Report of the Medical Officer of Health for the year 1910*, p. 12 (available from Wellcome Library, *London's Pulse*).

Figure 6 **Registrar General's reported infant mortality rates, 'corrected' Medical Officer of Health (MOH) infant mortality rates and indirect estimates from the 1911 census for six anomalous London registration sub-districts (RSDs), 1896–1910**



Note: The dotted grey lines are the interpolated trends, calculated from the corrected MOH infant mortality rates.

Sources: Registrar-General's *Quarterly Returns*; own calculations using data from Census of England and Wales, 1911,Vol. *XIII: Fertility of Marriage Part II* (London, 1923); Medical Officer of Health Reports available at Wellcome Library, *London's Pulse: Medical Officer of Health Reports 1848–1972*, https://wellcomelibrary.org/moh/ [accessed 8 December 2020].

'Glasshouse Yard' in the MOH area, but not the RSD.[65] Conversely, the MOH figures after 1900 appear to be aggregated for the same geographical area that the Registrar General defined as the Holborn RSD. The MOH figures have been used for the whole time period in Figure 5, but caution should be used in interpreting the earlier years, bearing this context in mind. The institution that significantly inflated the Registrar General's IMRs was the Children's Hospital (see cover illustration), although Holborn RSD was also home to the National Hospital, the London Homeopathic Hospital, the Italian Hospital and the St John and Elizabeth Hospital.[66]

IMRs for the Strand RSD were reported by two different administrative areas over the study time period, again due to the 1899 London Government Act. It is worth noting that the MOH figures are particularly variable due to the small number of births registered in this sub-district. By 1910, for example, only 145 births were registered in the Strand RSD (and 10 infant deaths).[67] According to Francis J. Allen, City of Westminster MOH, the population had decreased 'very considerably…due to improvement schemes connected more or less intimately with the new street from Holborn to the Strand' which was built in the 1890s.[68] Figure 6 shows the IMRs from all three sources plotted on the same graphs to highlight the inflation of the Registrar General's figures, as well as the similarity between the indirect estimates and MOH figures. The indirect estimates and MOH figures are thought to reflect better than do the Registrar General's figures the experiences of the resident married RSD population.

Having investigated the MOH reports extensively, it has become clear that the discrepancies between Registrar General's reported IMRs and the indirect estimates for the RSDs studied here were caused by the presence of public institutions within their boundaries. Such public institutions were driving patient migration from surrounding areas, thus falsely inflating the mortality rates recorded in the RSDs that were home to these institutions. In particular, the RSDs on which this paper has focused were home to large hospitals that would have taken infants or their pregnant mothers as patients. Table 3 lists the main hospital in each of the six RSDs investigated. All the hospitals listed in Table 3 (excluding Bolingbroke Hospital in South West Battersea) feature on Naomi Williams and Graham Mooney's list of 'key hospitals' in London: hospitals that were known for high mortality generally, but, more importantly, for their ability to cater for patients under the age of one year.[69] Additionally, the trends shown, and evidence found do not support the supposition that either population migration or illegitimate infant mortality was influencing the IMR in any of the RSDs to any great extent.

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65 W.A. Bond, *Report on the Vital Statistics and Sanitary Condition of the Holborn District, for the Year ending December 31st, 1896*, p. 9 (available from Wellcome Library, London's Pulse).

66 These institutions are listed in the annual MOH Reports for Holborn, an example of which is W.A. Bond, *The Metropolitan Borough of Holborn. Report for the Year 1907 of the Medical Officer of Health*, p. 11 (available from Wellcome Library, *London's Pulse*).

67 F.J. Allan, *Annual Report on the Statistics and Sanitary Condition relating to The City of Westminster for the year 1910,* p. 29 (available from Wellcome Library, *London's Pulse*).

68 F.J. Allan, *Annual Report on the Statistics and Sanitary Condition Relating to The City of Westminster for the year 1901,* p. 5 (available from Wellcome Library, *London's Pulse*).

69 Williams and Mooney, 'Infant mortality', p. 190.

Table 3 List of the most influential hospitals in each registration sub-district

Registration sub-district	Main hospital
Christchurch and St Saviour Southwark	Guy's Hospital
Holborn	Children's Hospital
South West Battersea	Bolingbroke Hospital
Strand	Kings College Hospital
St Sepulchre and All Hallows	St Bartholomew's Hospital
Whitechapel	London Hospital

Note: As well as Bolingbroke Hospital, Wandsworth and Clapham Union Infirmary were influential in inflating the infant mortality rate of South West Battersea.

Sources: Medical Officer of Health reports for various London districts: available at Wellcome Library, *London's Pulse: Medical Officer of Health Reports 1848–1972*, https://wellcomelibrary.org/moh/ [accessed 8 December 2020].

Shadwell and Ratcliff registration sub-district

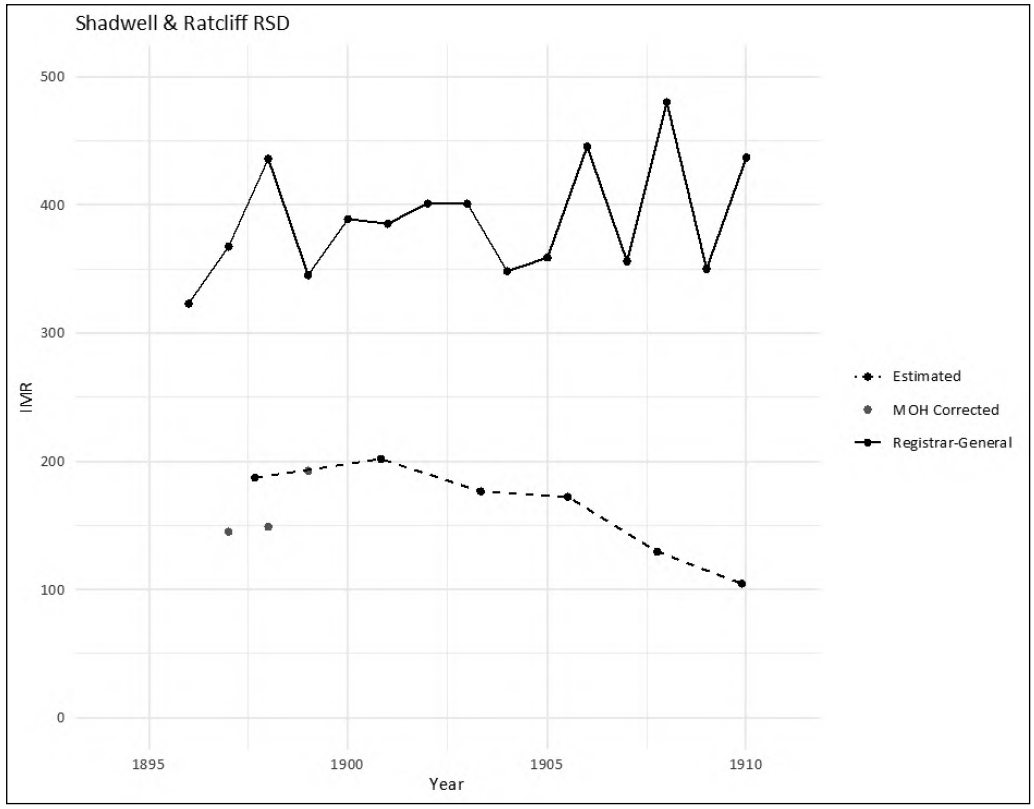
At the beginning of this study, Shadwell and Ratcliff was identified as an RSD that needed further investigation due to suspected inflated IMR reported by the Registrar General. However, when analysis of the MOH reports was undertaken, it soon became apparent that there was a lack of data available for the area covered by this RSD. Due to the London Government Act of 1899, Shadwell RSD and Ratcliff RSD moved from the jurisdiction of the 'Board of Works for the Limehouse District' to the 'Stepney Borough'. Unlike the other RSDs studied, Shadwell and Ratcliff was engulfed into the newer borough and the vital statistics for this geographical area were no longer reported explicitly. The Stepney Borough MOH reports gave IMRs for Limehouse District, St George's, Mile End, Whitechapel District and the whole Borough.[70] The Shadwell and Ratcliff RSD would have been included in the Limehouse District, but this was amalgamated with Limehouse RSD, and was therefore not directly comparable to the RSD of interest here.

Figure 7 shows the three points (1897, 1898 and 1899) that were collated from the earlier MOH Reports—where the IMR of the Shadwell and Ratcliff RSD was explicitly reported—plotted with the indirect estimates and the Registrar General's IMRs. From this, it is clear that the level of infant mortality recorded in the MOH reports was likely to be more accurate for the resident RSD population than that recorded in the Registrar General's returns. From the information that could be drawn from the MOH Report, it can be concluded that the Registrar General's IMR would have been skewed by the inflated number of infant deaths experienced in the East London Children's Hospital. This key hospital was situated in the Shadwell RSD and recorded 178, 219 and 117 infant deaths in the years 1897, 1898 and 1899 respectively. It is also featured on Williams and Mooney's list of 'key hospitals' in London.[71]

70 D.L. Thomas, *Annual Report of the Medical Officer of Health and Public Analyst for the Metropolitan Borough of Stepney. 1909*, p. 28 (available from Wellcome Library, *London's Pulse*).

71 D.L. Thomas, *Report on the Sanitary Condition of the Limehouse District, for the Year 1897*, p. 29 (available from Wellcome Library, *London's Pulse*); Thomas, *Report on the the Sanitary Condition of the Limehouse District 1898*,

Figure 7 **Registrar General's reported infant mortality rates, 'corrected' Medical Officer of Health (MOH) infant mortality rates where available, and indirect estimates from the 1911 census for the Shadwell and Ratcliff registration sub-district (RSD), 1896–1910**



Sources: Registrar-General's *Quarterly Returns*; own calculations using data from Census of England and Wales, 1911,*Vol. XIII: Fertility of Marriage Part II* (London, 1923); Medical Officer of Health Report for the Limehouse district available at Wellcome Library, *London's Pulse: Medical Officer of Health Reports 1848–1972*, https://wellcomelibrary.org/moh/ [accessed 8 December 2020].

Limitations

From this research, it is clear that the spatial patterns of infant mortality reported by the Registrar General experienced considerable distortions caused by the presence or absence of public institutions, such as hospitals, and therefore patient migration across the boundaries of registration sub-districts (RSDs). The two alternative sources assessed here have shown promise in removing such distortions and have provided IMRs that may be considered more accurate for the RSD resident populations. The indirect estimates from the 1911 census and the MOH reports are not without their own limitations, however. For

pp. 39–40; D.L. Thomas, *Report on the Sanitary Condition of the Limehouse District, for the Year 1899*, p. 30 (available from Wellcome Library, *London's Pulse*)' Williams and Mooney, 'Infant mortality', p. 190.

example, both suffer from under-enumeration and therefore are likely to be marginally underestimating IMRs.[72]

When considering the indirect estimates, it is also important to be aware of the fluidity of the population of London, due to both migration within the capital, and the migration of people from and to other parts of the country and abroad.[73] For the seven RSDs studied in detail here, there was no evidence to suggest that population migration influenced the indirect estimates of infant mortality significantly. This indeed was also the case for Bethnal Green over the same time period: despite the high population turnover and an increasing proportion of Eastern European migrants (from less than 1 per cent of married women in 1891, to 20 per cent in 1911), the 'distortion caused, even by a considerable influx of immigrants, [was] relatively small'.[74] This may, however, not always be the case when employing indirect estimation techniques.

Due to the changing administrative areas within London and the somewhat individualistic nature of the MOH Reports, another limitation of this source was the lack of consistency. The reports do not necessarily provide consistent annual IMRs for the required geographical areas. It can therefore be a time-consuming task to trawl through the reports to collate and then understand the data. Knowledge of how the administrative boundaries and jurisdictions change over time helped with this, but did not alleviate the issues fully, as seen by the gap in the Sepulchre and All Hallows data and lack of data for Shadwell and Ratcliff.

The data collated in the MOH reports were also limited by the information that the MOHs asked for and received. In particular, they did not consistently receive the numbers of deaths of residents outside of their administrative area, leading to under-enumeration of these events. Higgs uncovered evidence that the London Local Government Board had tried to persuade the MOHs to redistribute institutional deaths between themselves during the 1890s. This, however, was clearly not a great success. Higgs described that the 'MOHs "exporting" deaths were quite happy to co-operate but those expected to "import" them, thus increasing local levels of mortality, were less keen'.[75] This narrative concurs with the evidence found in this paper. The lack of consistent redistribution of non-resident infant deaths in institutions also meant that some infant deaths may not have been included in any of the RSD IMRs, which could prove problematic for statistical analyses.

Conclusion

The research reported in this paper has highlighted the need for caution when using the Registrar General's figures for infant mortality before 1911, when the consistent

72 For the indirect estimates, 'under-enumeration' refers to the exclusion of unmarried mothers in their calculations, and for the MOH reports this refers to the exclusion of resident infant deaths recorded in institutions outside their district in their figures.

73 Schurer and Day, 'Migration to London', pp. 41–2.

74 Garrett *et al.*, *Changing Family Size,* p. 458.

75 Higgs, 'Statistical Big Bang', p. 424.

redistribution of deaths to usual place of residence began. This is particularly important in urban contexts where public institutions were more common, and especially for areas with smaller populations, such as RSDs. It has been shown that the extent to which the presence of an institution might inflate an RSD's rate of infant mortality can be dramatic, with some true rates doubling and others increasing almost eight-fold. These heavily skewed IMRs caused by patient migration across RSD boundaries to key public institutions have the potential to influence statistical analysis and could produce biased results.

Two alternative sources for deriving RSD IMRs have been considered, and it is concluded that they are both likely to give a truer reflection of the experience of the married, resident population of an RSD than the distorted Registrar General's figures. Indirect estimates from the 1911 Fertility Census have been shown to portray accurately the level and smoothed trend of RSD IMRs in the years leading up to the census. 'Corrected' IMRs provided by the MOHs could be used in analyses instead of the Registrar General's figures because they exclude the influence of institutions which inflated the IMRs of some RSDs. Saying this, it is important to be cautious of the unsystematic nature of the removal of non-resident infant deaths within the various MOH reports, which changed over time and by administrative area. At the very least therefore, it is imperative to control for institutional deaths in statistical models wherever possible.

Despite the limitations of the two alternative methods discussed, the triangulation of all three sources has proved a fruitful and worthwhile method of both further understanding and tackling the problem of inflated IMRs recorded in the Registrar General's returns. The methods suggested here provide at least partial solutions to the problem of the Registrar General not systematically redistributing institutional deaths between small geographical units. They will help to provide a more nuanced understanding of the reporting of IMRs in London during the period 1896 to 1911.

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