Vaccine 36 (2018) 4062–4069

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine

Assessment of on-time vaccination coverage in population subgroups: A record linkage cohort study

Hannah C. Moore [a,*], Parveen Fathima [a], Heather F. Gidding [b,c], Nicholas de Klerk [a], Bette Liu [b], Vicky Sheppeard [d], Paul V. Effler [e], Thomas L. Snelling [a,f,g,h], Peter McIntyre [c], Christopher C. Blyth [a,f,i,j], on behalf of the ACIR Linkage Investigator Group

[a] Wesfarmers Centre of Vaccines and Infectious Diseases, Telethon Kids Institute, The University of Western Australia, PO Box 855, West Perth, WA 6872, Australia
[b] School of Public Health and Community Medicine, UNSW Medicine, The University of New South Wales, Samuels Avenue, Kensington, NSW 2033, Australia
[c] National Centre for Immunisation Research and Surveillance, The Children's Hospital at Westmead, Locked Bay 4001, Westmead, NSW 2145, Australia
[d] Communicable Diseases Branch, NSW Health, Locked Mail Bay 961, North Sydney, NSW 2059, Australia
[e] Communicable Diseases Control Directorate, WA Department of Health, PO Box 8172, Perth, WA 6849, Australia
[f] Princess Margaret Hospital for Children, Roberts Rd, Subiaco, WA 6008, Australia
[g] Curtin University, School of Public Health, GPO Box U1987, Perth 6845, Australia
[h] Menzies School of Health Research and Charles Darwin University, PO Box 41096, Casuarina, NT 0811, Australia
[i] Department of Medicine, The University of Western Australia, Roberts Rd, Perth, WA 6008, Australia
[j] PathWest Laboratory Medicine WA, QEII Medical Centre, Hospital Ave, Nedlands, WA 6009, Australia

ARTICLE INFO

Article history:
Received 24 January 2018
Received in revised form 3 May 2018
Accepted 22 May 2018
Available online 31 May 2018

Keywords:
Vaccine coverage
Timeliness
Infant
Population
Diphtheria-tetanus-pertussis

ABSTRACT

Reported infant vaccination coverage at age 12 months in Australia is >90%. On-time coverage of the 2–4–6 month schedule and coverage in specific populations is rarely reported. We conducted a population-based cohort study of 1.9 million Australian births, 1996–2012, combining individual birth and perinatal records with immunisation records through probabilistic linkage. We assessed on-time coverage across 13 demographic and perinatal characteristics of diphtheria-tetanus-pertussis vaccines (DTP) defined as vaccination 14 days prior to the scheduled due date, to 30 days afterwards. On-time DTP vaccination coverage in non-Aboriginal infants was 88.1% for the 2-month dose, 82.0% for 4-month dose, and 76.7% for 6-month dose; 3-dose coverage was 91.3% when assessed at 12 months. On-time DTP coverage for Aboriginal infants was 77.0%, 66.5%, and 61.0% for the 2–4–6 month dose; 3-dose coverage at 12 months was 79.3%. Appreciable differences in on-time coverage were observed across population subgroups. On-time coverage in non-Aboriginal infants born to mothers with ≥3 previous pregnancies was 62.5% for the 6-month dose (47.9% for Aboriginal infants); up to 23.5 percentage points lower than for first-borns. Infants born to mothers who smoked during pregnancy had coverage 8.7–10.3 percentage points lower than infants born to non-smoking mothers for the 4- and 6-month dose. A linear relationship was apparent between increasing socio-economic disadvantage and decreasing on-time coverage. On-time coverage of the 2–4–6 month schedule is only 50–60% across specific population subgroups representing a significant avoidable public health risk. Aboriginal infants, multiparous mothers, and those who are socio-economically disadvantaged are key groups most likely to benefit from targeted programs addressing vaccine timeliness.

1. Introduction

Immunisation is one of the most effective public health prevention strategies worldwide. The National Immunisation Program (NIP) in Australia incorporates a 3-dose infant schedule at 2–4–6 months of age including vaccines against diphtheria, tetanus, pertussis, poliomyelitis, hepatitis B, *Haemophilus influenzae* type B, pneumococcal disease and rotavirus. The Australian Immunisation

Abbreviations: ACIR, Australian Childhood Immunisation Register; AIR, Australian Immunisation Register; ARIA, Accessibility/Remoteness Index for Australia; DPT, Diptheria-Tetanus-Pertussis; IRSAD, Index of Relative Socio-Economic Disadvantage; NSW, New South Wales; PCV, Pneumococcal Conjugate Vaccine; WA, Western Australia.

* Corresponding author.
E-mail address: hannah.moore@telethonkids.org.au (H.C. Moore).

https://doi.org/10.1016/j.vaccine.2018.05.084
0264-410X/

Register (AIR), one of only a few population-based vaccine registers worldwide, is used to report immunisation coverage. This is normally assessed at age 12 months using 3-monthly cohorts [1]. Coverage is measured using the 'third dose assumption' which defines a child as fully immunised if a third dose of a particular vaccine course is recorded regardless of whether the first or second doses are recorded [2]. Using this method, coverage rates in Australia of vaccines on the NIP schedule (excluding rotavirus) are reported as over 90% [3]. The population-level coverage of each vaccine at time points closer to the scheduled ages of 2, 4 and 6 months are not routinely examined, but might be an important indicator of on-time vaccination coverage. Delayed vaccination, particularly in high risk children including Aboriginal and/or Torres Strait Islander children (hereinafter referred to as Aboriginal), could be contributing to the continued high rates of some vaccine preventable diseases and the large disparity between Aboriginal and non-Aboriginal children for many infectious diseases [4,5].

Linkage of birth and perinatal records to the AIR allows accurate assessment of population-level coverage close to the scheduled vaccination time, using the number of births in the population as the denominator. More importantly, the only demographic information that is recorded on AIR is the child's age, sex, residential postcode and Aboriginal status; therefore calculation of coverage within particular population subgroups (including those born preterm, or from lower socio-economic areas) is only possible through combining information from multiple datasets with record linkage. The assessment of vaccination coverage in population subgroups might allow identification of specific demographic groups that would benefit most from targeted strategies to improve timeliness. A recent systematic review identified higher birth order, low maternal education and low socio-economic status to be the most cited factors associated with incomplete or delayed vaccination [6], although factors relating to social determinants of uptake have been shown to be context specific [7] and have not been assessed in minority populations such as indigenous populations. Using an assembled linked dataset of perinatal and birth records linked to immunisation records, we assessed 'on-time' immunisation coverage of the 2–4–6 month schedule in Australia by population subgroup, focusing on the uptake of diphtheria-tetanus-pertussis vaccines (DTP) among Aboriginal and non-Aboriginal infants. We hypothesised that coverage would vary among subgroups and that on-time coverage would be lower than routinely reported coverage at 12 months.

2. Patients and methods

2.1. Study population

The study population was defined as all live births in Western Australia (WA) and New South Wales (NSW) between 1996 and 2012. WA and NSW together represent 42% of Australia's population. The full details of assembling the linked dataset through probabilistic linkage across three linkage centres are provided elsewhere [8,9]. In brief, the cohort comprised 1,953,881 infants that had both a registered birth record and a perinatal data record. Aboriginal status was derived using a multi-stage median algorithm, described previously [10] using information from all linked datasets in the study, excluding deaths, and based on Australia's national best practice guidelines for data linkage activities relating to Aboriginal and Torres Strait Islander people [11]. Using this validated algorithm, 5% of our cohort (97,778) were identified as Aboriginal.

2.2. Vaccination records

The AIR (previously known as the Australian Childhood Immunisation Register, ACIR) contains information regarding the date, dose number and types of vaccines given and the type of health service that provided the vaccine. DTP immunisation records for the study cohort between 1996 and 2013 were extracted from AIR and probabilistically linked at the Australian Institute of Health and Welfare as described previously [8,9]. In brief, immunisation data from AIR were linked to the birth register based on a matched linkage rate of 99.3% (similar to a sensitivity measure) with a corresponding linkage accuracy of 99.0% (similar to a positive predictive value measure). Duplicate immunisation records with the same immunisation date and vaccine dose number were removed. Records with the same immunisation date but different vaccine dose number were combined, retaining the record with the most recent date of recording in AIR. Vaccination records that did not have a corresponding birth cohort record were removed as were records of infants where the date of immunisation was before the child's date of birth on their associated perinatal data record [9]. These exclusions from the cohort equated to 1% of all cohort members (Fig. 1). Records pertaining to pneumococcal conjugate vaccines (PCV) for which a national program commenced in 2005 were also analysed with details provided as Supplementary Information.

In order to measure coverage at each scheduled infant dose, we chose time-windows reflecting on-time receipt. A 30-day time period from the expected date of vaccination has been used previously as the standard measure of on-time vaccination [12]. For all infants in the birth cohort, we calculated the age in days at vaccination for each dose at 2, 4 and 6 months of age. A vaccination record within a 3 day window prior to the scheduled date of a 2-month dose up until 30 days after the scheduled date was considered an on-time vaccination dose. A vaccination record within a 2 week window prior to the expected date up until 30 days after the expected date was considered an on-time vaccination dose for the 4- and 6-month dose. This assessment means that on-time receipt of the 2-month dose was defined as vaccination from age 39 days (the first DTP dose can be administered from 6 weeks and allowing a 3 day grace period) to age 90 days, the window for the 4-month dose was defined as age 106–150 days and the window for the 6-month dose was defined as age 166–210 days.

2.3. Population subgroups

We selected maternal, paternal and infant factors from the linked birth register and perinatal datasets *a priori* based on available literature [6]. Maternal and paternal factors included age at time of their child's birth in four discrete age groups, maternal smoking during pregnancy, number of previous births and mother's country of birth (Australia vs overseas). Infant and birth related factors included Aboriginal status, sex, season of birth (summer [December-February], autumn [March-May], winter [June-August], spring [September-November]), mode of delivery (vaginal, caesarean, instrumental), prematurity across three gestational age groups, birthweight across 5 groups, state of birth, socio-economic status measured through the Index of Relative Socio-Economic Advantage and Disadvantage (IRSD) and remoteness as measured through the Accessibility/Remoteness Index of Australia (ARIA). The IRSAD is one of four Socio-Economic Indexes for Areas. Each index measures a different aspect of the socio-economic conditions of the people living in a particular area and ranks different geographical areas across Australia according to a score created from the characteristics in that area [13]. The IRSAD score is derived from 17 variables including income, internet connection, unemployment and education [13] and is grouped into five categories ranging from most disadvantaged (index scores below the 10th percentile) to least disadvantaged (index scores above the 90th percentile). ARIA is a standard national measure of remoteness and access to services for localities and areas throughout