Innovative applications of immunisation registration information systems: example of improved measles control in Taiwan

D P Liu^{1,2}, E T Wang³, Y H Pan³, S H Cheng (shcheng@ntu.edu.tw)²

1. Epidemic Intelligence Center, Centers for Disease Control, Ministry of Health and Welfare, Taiwan
2. Institute of Health Policy and Management, National Taiwan University, Taiwan
3. Division of Acute Infectious Diseases, Centers for Disease Control, Ministry of Health and Welfare, Taiwan

Citation style for this article:

Liu DP, Wang ET, Pan YH, Cheng SH. Innovative applications of immunisation registration information systems: example of improved measles control in Taiwan. *Euro Surveill.* 2014;19(50):pii=20994. Available online: <http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=20994>

Article submitted on 10 October 2013 / published on 18 December 2014

Immunisation registry systems have been shown to be important for finding pockets of under-immunised individuals and for increasing vaccination coverage. The National Immunisation Information System (NIIS) was established in 2003 in Taiwan. In this perspective, we present the construction of the NIIS and two innovative applications, which were implemented in 2009, which link the NIIS with other databases for better control of measles. Firstly, by linking the NIIS with hospital administrative records, we are able to follow up contacts of measles cases in a timely manner to provide the necessary prophylaxis, such as immunoglobulin or vaccines. Since 2009, there have been no measles outbreaks in hospitals in Taiwan. Secondly, by linking the NIIS with an immigration database, we are able to ensure that young citizens under the age of five years entering Taiwan from abroad become fully vaccinated. Since 2009, the measles-mumps-rubella vaccine coverage rate at two years of age has increased from 96% to 98%. We consider these applications of the NIIS to be effective mechanisms for improving the performance of infectious disease control in Taiwan. The experience gained could provide a valuable example for other countries.

Introduction

Immunisation is the most effective and efficient way to prevent vaccine-preventable diseases. However, the appropriate coverage rate is still critical for a comprehensive immunisation programme, especially for highly contagious diseases such as measles. The World Health Organization (WHO) recommends that countries should achieve coverage greater than 95% for a two-dose measles-containing vaccine in every district to eliminate measles [1]. The WHO European Region has set 2015 as the target for interrupting transmission of measles and rubella [2]; however, according to the *2014 Assessment report of the global vaccine action plans* [3], among the three WHO regions aiming for measles elimination by the end of 2015, the Eastern Mediterranean Region and

the European Region 'are markedly off track'. The WHO Western Pacific Region has made the most progress, but outbreaks in China, the Philippines and Vietnam in 2013 proved a setback. National coverage is above 95% in many countries in the three WHO regions, but 'just one weak district is enough for this highly contagious virus to continue circulating' [3].

In many countries, comprehensive immunisation registry information systems are well established and have proved helpful in identifying pockets of under-immunised individuals and improving vaccination coverage [4]. This perspective aims to present innovative applications of the system used for measles prevention and control in Taiwan and to share the preliminary experiences. New concepts of immunisation database linkage could help to address the weakness in measles control in mobile populations and within medical settings, even in countries with comprehensive vaccination policies.

Taiwan is well known for its information technology industry, and technology advances have been readily adopted in health management for over 20 years. The Primary Health Information System (PHIS) was first established for public health stations in every township in the 1990s. The vaccination registry system was developed independently and was extended to a web-based system to fulfil the demand to keep up with the mobile population of Taiwan. The planning and construction of a new registry system, the National Immunisation Information System (NIIS), started in 2001. Since the end of 2003, the system has been operating online, running at all public health bureaus in 25 counties/cities and public health stations in all 373 townships. It took a year to train the users and to extend its use from government public health services to all of the 1,600 contract clinics and hospitals, covering all service points nationwide. Since 2005, all of the local health agencies have been participating in the

FIGURE 1

Structure and information flow of the National Immunisation Information System in Taiwan

CDC: Centers for Disease Control; HPA: Health Protection Administration; MOH: Ministry of Health and Welfare; MOI: Ministry of the Interior; NHI: National Health Insurance Administration; NIA: National Immigration Agency; NIIS: National Immunisation Information System.

^a Elementary schools: for children 6 to 11 years of age.

^b Infant's faeces card: NIIS has a function reminding healthcare workers to check and record stool colour of infants for early diagnosis of biliary atresia.

NIIS and upload complete information to a central database. As several imported measles cases and clusters occurred from the end of 2008 to spring 2009 [5], NIIS data linkage was considered in 2009 to help to control the disease.

The National Immunisation Information System

The NIIS contains most of the information for immunisation affairs, including an immunisation registry, vaccine management, lists of unvaccinated children, reports of coverage rates and related statistics. For example, once a baby is born in Taiwan, hepatitis B vaccine is administered within 24 hours and the baby is registered in an interim NIIS account by the clinic or hospital. Hepatitis B carriage status at the prenatal examination is also recorded in the system. By matching the baby with the mother's ID, hepatitis B immunoglobulin can be provided in a timely manner to high-risk newborns. After three to four weeks, when the baby gets its ID number, a permanent account is generated to replace the interim one in the NIIS, and the parent or guardian's name and address are updated by transferring data

from the Ministry of the Interior's National Household Information System every 24 hours. Through this mechanism, the NIIS database has been able to cover the whole population born after 1995 in Taiwan. More detailed contact information is provided by the parents or guardians voluntarily and is recorded in the NIIS, including mobile telephone numbers in over 50% of cases. All of the subsequent vaccination doses for the baby are recorded in the ID account and compiled through the data exchange between the NIIS local and central databases. This mechanism allows children to be vaccinated anywhere in the country and helps to ensure that all the immunisations will not be missed or repeated. In addition, related information such as vaccination dose, place, time and lot number is also required on the data entry sheet: NIIS records are also critical for vaccine safety investigation. The structure of the NIIS is demonstrated in Figure 1.

Before computerisation, it was impossible to calculate immunisation coverage rates precisely using paper records. From 1986 to 1994, the Taiwan national vaccination coverage rates were estimated through surveys for

FIGURE 2

Measles-containing vaccine coverage, compared with coverage of the third dose of diphtheria-tetanus-pertussis vaccine, and number of measles cases (n=3,467), Taiwan, 1986–2012

DTP3: third dose of diphtheria-tetanus-pertussis vaccine at six months of age (since 1955); MMR: measles-mumps-rubella; MMR1-12M: first dose of MMR vaccine at 12 months of age (since 1992; national coverage data available since 1996); MMR2-first graders: second dose of MMR vaccine for children aged six to seven years old (since 2001); MV-9M: measles-containing vaccine scheduled to be vaccinated at nine months of age (from 1978 to 2005; national coverage data available since 1986); NIIS: National Immunisation Information System; PHIS: Primary Health Information System.

sampled counties every one to three years. As the PHIS was being constructed, the coverage for each administration area became available. After the construction of the NIIS, local records could be integrated and updated for every individual; all of the PHIS records since 1995 were compiled into the NIIS central database. Since then, public health workers have been able to follow up on unvaccinated individuals easily, and the coverage rates for measles-containing vaccines and the third dose of diphtheria-tetanus-pertussis vaccine (DTP3) have been increasing and maintained at over 95% since 2001 (Figure 2). NIIS data show that the coverage rates for other childhood vaccinations have all reached and been maintained at $\geq 95\%$ for the primary doses, so higher standards for timeliness and completeness have also been set by the Taiwan Centers for Disease Control (CDC). For example, in 2012 in Taiwan, measles-mumps-rubella (MMR) vaccine coverage by 15 months

of age (scheduled to be vaccinated at 12 months-old) was 88.8%. Coverage of MMR vaccination at 12 months is usually calculated when the child is aged 18 or 24 months. Checking vaccination status at 15 months of age will protect children earlier and decrease the number of post-vaccination seizures, but a lower vaccination rate at this time point is also expected. As the time available to trace unvaccinated children and complete their vaccination is shorter (as checked at 15 months of age), coverage of 88.8% is considered good. Full immunisation in children at two years of age (i.e. they have received one dose of *Bacillus Calmette–Guérin* (BCG) vaccine, varicella vaccine and MMR vaccine, two doses of Japanese encephalitis vaccine, three doses of hepatitis B vaccine, four doses of DTP-*Haemophilus influenzae* type b-inactivated polio vaccine) was 94.1%. The index ‘full immunisation coverage’ is much more stringent than coverage for an individual vaccine, as a child

TABLE

Follow-up activities for contacts (aged six years or less) of measles cases who presented at hospital, Taiwan, 2009–2012 (n=640)

Hospital	Month, year	Contacts traced ^a							
		Under one year of age				1–6 years of age			
		Number	Followed up	IMIG administration ^b	Infected ^c	Number who had not received MCV	Followed up	Vaccinated	Infected ^c
A	Feb 2009	13	13	5	1	10	10	9	1
B	Mar 2009	264	264	43	0	85	85	64	0
C	Mar 2009	88	88	2	2	24	23	22	0
D	May 2009	42	42	22	1	14	14	13	0
E	Jul 2010	12	12	6	0	37	37	36	0
F	Jun 2011	49	49	36	0	2	2	2	0
Total	–	468	468	114	4	172	171	146	1

IMIG: intramuscular immunoglobulin; MCV: measles-containing vaccine.

^a Once the exposure has been reported, the contacts should be identified and followed up with within 48 hours. Follow-up activities include checking for symptoms and signs, evaluation for providing IMIG or vaccination, and health education.

^b IMIG administered was within six days after the exposure in contacts under one year of age for whom it was determined to be necessary.

^c None of the five contacts infected received post-exposure prophylaxis.

has to receive all the recommended doses; coverage of over 90% for children aged two years is not easy to obtain.

Two innovative applications for measles prevention and control that link the NIIS with other data sources are described below.

Application 1: linking the National Immunisation Information System with hospital administrative records to identify and prevent potential measles transmission within hospitals

Medical facilities have been considered high-risk settings for measles transmission [6,7]. In Taiwan, there were three measles outbreaks resulting in 22 cases from five hospitals across Taiwan from November 2008 to February 2009 [5]. To address within-hospital measles transmission, the Taiwan CDC requires hospitals to provide them with a list with names of possible contacts when a measles case is identified. A possible measles contact is defined as any person present in the same room or ward 30 minutes before or two hours after an infectious measles patient (four days before or after rash onset [8]) stayed there. With a universal health insurance scheme, relatively low co-payment for visiting a doctor and completely free choice of health-care providers, however, ‘doctor shopping’ is frequent in Taiwan [9]; consequently, a person with measles may have visited several clinics or hospitals before being diagnosed. Public health workers thus face difficulties to identify large numbers of contacts in health-care facilities and to follow them up in time.

Since February 2009, all contacts of measles cases who presented to a hospital have been identified via the hospital’s computerised health information system.

The electronic files of the names of the contacts, with their ID numbers are put into the NIIS, to check the contacts’ vaccination history. Children under six years-old have been considered a high-risk group: the first priority is those under one year of age, who are evaluated for administration of intramuscular immunoglobulin (IMIG). Parents or guardians of children from one to six years-old without complete vaccinations are contacted immediately and the children are vaccinated as soon as possible. Other contacts (or their parents or guardians, if the contact is a child older than six years) will receive a letter informing them of the exposure and giving them recommended self-health management advice.

As it takes only five minutes to check the vaccination records of hundreds of contacts using an NIIS batch-screening function, public health workers can identify high-risk contacts and take the necessary actions in a timely manner. From February 2009 to 2012, there were six occurrences of large-scale measles exposure in Taiwanese hospitals, with between 556 and 1,266 contacts identified per case. After screening the contacts’ vaccination history through the NIIS, almost all (639/640) of those who were susceptible to measles completed follow-up (Table). Through linkage with the NIIS database and with a rapid response, 146 individuals were vaccinated within three days after exposure. Among those contacts under one year of age (n=468), 114 were considered to have required post-exposure prophylaxis and IMIG was provided within six days after exposure. As measles cases are infectious four days before rash onset [8], five contacts were exposed to three cases during the infectious period and were identified too late after exposure to benefit from prophylaxis and subsequently developed measles. Nevertheless, all the contacts who received post-exposure prophylaxis remained free of symptoms and there

has been no measles outbreak in hospitals since the intervention in 2009.

To maintain the achievement of measles elimination in the WHO Region of the Americas, high standards of case investigation and containment measures have cost vast resources in the United States [7,10]. The experience in Taiwan presented here shows that by batch-screening vaccination histories, public health workers were able to identify high-risk hospital contacts quickly and take the necessary actions accordingly, saving time and manpower in checking vaccination status, and enabling them to trace contacts at low risk.

Application 2: linking the National Immunisation Information System with immigration records to monitor children entering Taiwan without measles vaccination

During 2007 to 2009, eight of 18 measles cases imported to Taiwan were incompletely vaccinated children returning from travel abroad with their parents (unpublished data). Such travel may lead to missed vaccination opportunities according to the Taiwanese vaccination schedule. For example, from 1998 to 2012, 10% of the babies in Taiwan were born to mothers from other countries [11]: these mothers may have travelled with their babies to visit their homeland within one year after the birth. In addition, measles case investigation reports and feedback from public health workers involved in tracing unvaccinated children showed that increasing numbers of families travelled back and forth between mainland China and Taiwan for work during 2007 and 2009.

Given the above, the Taiwan CDC called for assistance from the National Immigration Agency. Since February 2009, immigration records have been provided to the Taiwan CDC on a daily basis and have been linked with the NIIS database. Any child in the NIIS under five years of age with no record of MMR vaccination in Taiwan is identified, and public health workers attempt to contact the parents or family members as soon as possible. The records are completed if the child has already been vaccinated abroad, or MMR vaccine is offered immediately.

From February 2009 to May 2010, a total of 206,367 children entered Taiwan [12]; among them 9,961 were without measles vaccination and were identified via the data-linking process. Follow-up was successfully carried out for 5,185 (52%) of them. Among these children, 3,114 were vaccinated according to Taiwan's immunisation schedule as soon as possible; the others (n=2,071) presented certificates of vaccination from abroad and their NIIS records were updated. In 2012, a total of 4,975 children entering Taiwan without MMR vaccination were identified, and 2,627 (53%) were successfully followed up. The reasons some children could not be followed up included travelling abroad again, no longer living at the known address, no one answered when called by telephone or visited, or the telephone

number or address were unavailable. Because of the implementation of this project, the coverage rate of the first dose of MMR vaccine for children aged two years since 2009 has increased from 96% to roughly 98%. As second-dose vaccination (recommended to be administered at six years of age) is a school-based programme and elementary school (for 6–11 year-olds) attendance rate in Taiwan is high – for example, 99.52% for the 2013 school year [13] – coverage of the second dose of MMR vaccine is over 97%; thus, the NIIS has only a limited effect on it. Since 2012, when other vaccines were also included for follow-up using this NIIS data linkage mechanism, the coverage of DTP3 increased to 98% (from 95% in 2006) (Figure 2).

Although there are very effective and safe vaccines to control measles, the coverage of measles-containing vaccines is still a key issue, even in industrialised countries [14]. In addition, industrialised countries are at increasing risk because of migration, air travel and working personnel exchange due to global economic mobility. Inconsistencies between vaccination rates and measles incidence have been found in some instances [15,16] and supplementary immunisation activity is not always as effective as is expected [17]; all of these issues could be a result of unreliable coverage calculation, repeated vaccinations or recordings, and, ultimately, failure to reach vulnerable populations, for example, mobile populations and abused children. A comprehensive registry information system could help to find any weaknesses regarding vaccination and thus help in trying to solve them. Optimal methods for estimating vaccination coverage and additional strategies for achieving high coverage in migrant, nomadic and displaced populations have been identified as research priorities for global measles and rubella control and eradication [18].

Experiences and challenges

The development of a new information system under the public health administration was not an easy task. In the beginning, the construction of Taiwan's NIIS experienced resistance from users in local health agencies because they had been accustomed to working only with paper documents for many years. To understand users' opinions and the system's effectiveness, the Taiwan CDC conducted two comprehensive surveys, at the end of 2003 and 2004. The surveys indicated that users complained about the change at first but that satisfaction rates improved greatly a year after the project was implemented [19]. With the recognition that children could move around and get vaccinated in any part of Taiwan and that a centralised database was needed, all of the local health agencies finally agreed to participate in the NIIS in 2005.

Despite the support for the information system, immunisation programs still rely on the performance of public health workers and clinicians. Unfortunately, compared with medical care services (24/56 practicing doctors/nurses per 10,000 population in Taiwan

in 2010 [20]; 32/88 respectively per 10,000 population for member countries of the Organisation for Economic Co-operation and Development in 2011 [21]), the resources allocated for public health in Taiwan are relatively insufficient. In 2013, there were only 3,429 first-line public health workers at local health bureaus and stations, i.e. 1.5 public health workers per 10,000 population (unpublished data). The NIIS has provided an efficient way to reduce interface costs and provide greater consistency in data exchange. We also noticed that in both of the examples presented in this article, intersectoral cooperation was essential for both the public (immigration or household registry agencies) and private (medical facilities participating in the NIIS) sectors. In addition to comprehensive legislation that gave the authority for disease control policies to be enforced, awareness of the benefits of immunisation and commitment to better disease control play key roles in the success of these extended applications of the NIIS.

The power of linking databases with immunisation information systems has been shown [22-24], mostly involving links with health records. Linking a hospital's information concerning measles contacts to the NIIS can help to prevent secondary transmission at a hospital. To the best of our knowledge, linking an immunisation information system with immigration records is a new concept. For infectious diseases, particularly in the context of rapid and extensive world travel, there is a need for systematic, concerted cooperation among government agencies. Moreover, unvaccinated children are usually at high risk and may be difficult to reach. Linking the NIIS with the immigration database facilitated successful follow-up of over 50% of the target population. The other 50% were mobile, either people who had left Taiwan again or whose contact information was unavailable or incorrect. With better collaboration among health, social and educational departments, an even higher percentage of follow-up may be attainable. By using innovative applications of immunisation information systems, it is possible to achieve over 95% vaccine coverage and timely case investigation and intervention.

One issue concerning the application of immunisation information systems is the protection of personal information; however, regional or national immunisation information systems do exist and, as of 2012, were compliant with national data protection laws in 14 countries in the European Union [25]. Examples of using immunisation information systems and other databases with personal details to promote public health are present in Australia, Canada and the United States [22-24]. In Taiwan, the Personal Information Protection Act states that the government agency should use personal information in accordance with the scope of its job functions provided by laws or regulations, and in compliance with the specific purpose of collection [26]. However, the information may be used outside this scope when it is used to prevent

harm to life, body, freedom or property and where it is used to prevent harm to the rights and interests of other people. This legislative process was not developed specifically for NIIS linkage and parents do not have to give explicit permission for data linkage. With a rigorous policy review and compliance with national data protection laws in Taiwan, public trust in data collection and linking of databases with the NIIS has been maintained and public health protected and promoted. With the necessary protection of personal information, the experience of Taiwan's immunisation information system and its application could be valuable for other countries now that international travel and workforce exchanges have become commonplace.

Acknowledgements

The authors would like to thank Tong-Ping Chang for preparing the figure of NIIS structure, and Steven Fox, Fu-Tien Lin, Shu-Fong Chen and Li-Min Huang for helpful discussions. The study was supported by a grant from the National Health Research Institute (NHRI-EX102-10225PI) in Taiwan. The funding source had no role in the study.

Conflict of interest

None declared.

Authors' contributions

Ding-Ping Liu, En-Tzu Wang and Yi-Hsin Pan were involved in collection of data and information. Ding-Ping Liu drafted the manuscript, which was reviewed by Shou-Hsia Cheng.

References

1. Measles vaccines: WHO position paper. *Wkly Epidemiol Rec.* 2009;84(35):349-60. PMID:19714924
2. WHO Regional Office for Europe. European Vaccine Action Plan 2015-2020. Copenhagen: The Regional Office for Europe of the World Health Organization; 2014. Available from: http://www.euro.who.int/__data/assets/pdf_file/0007/255679/RC-background-doc-European-Vaccine-Action-Plan-2015-2020.pdf?ua=1
3. Strategic Advisory Group of Experts on Immunization. 2014 Assessment report of the global vaccine action plans. Geneva: WHO; 2014. Available from: http://www.who.int/immunization/global_vaccine_action_plan/SAGE_DoV_GVAP_Assessment_report_2014_English.pdf
4. Pebody R. Vaccine registers--experiences from Europe and elsewhere. *Euro Surveill.* 2012;17(17). pii:20159. PMID:22551493
5. Chen JH, Tsou TP, Liu DP. Measles resurgence in Taiwan--lessons learned. *J Formos Med Assoc.* 2009;108(4):267-9. [http://dx.doi.org/10.1016/S0929-6646\(09\)60065-6](http://dx.doi.org/10.1016/S0929-6646(09)60065-6) PMID:19369172
6. Choi WS, Sniadack DH, Jee Y, Go UY, So JS, Cho H, et al. Outbreak of measles in the Republic of Korea, 2007: importance of nosocomial transmission. *J Infect Dis.* 2011;204(Suppl 1):S483-90. <http://dx.doi.org/10.1093/infdis/jir087> PMID:21666204
7. Chen SY, Anderson S, Kutty PK, Lugo F, McDonald M, Rota PA, et al. Health care-associated measles outbreak in the United States after an importation: challenges and economic impact. *J Infect Dis.* 2011;203(11):1517-25. <http://dx.doi.org/10.1093/infdis/jir115> PMID:21531693
8. Measles. In: Heymann DL, editor. *Control of communicable diseases manual*. 19th ed. Washington DC: American Public Health Association; 2008. p. 402-8.
9. Cheng TM. Taiwan's new national health insurance program: genesis and experience so far. *Health Aff (Millwood)*.

- 2003;22(3):61-76. <http://dx.doi.org/10.1377/hlthaff.22.3.61> PMID:12757273
10. Dayan GH, Ortega-Sánchez IR, LeBaron CW, Quinlisk MP; Iowa Measles Response Team. The cost of containing one case of measles: the economic impact on the public health infrastructure--Iowa, 2004. *Pediatrics*. 2005;116(1):e1-4. <http://dx.doi.org/10.1542/peds.2004-2512> PMID:15995008
 11. Department of Statistics. Ministry of the Interior, Taiwan. Number and rates of birth, death, marriage and divorce. Taipei: Ministry of the Interior. [Accessed 12 Dec 2014]. Available from: <http://sowf.moi.gov.tw/stat/month/m1-02.xls>
 12. Department of Statistics. Ministry of the Interior, Taiwan. [Statistics inquiry: citizens back to Taiwan, by age and sex]. Taipei: Ministry of the Interior. [Accessed 12 Dec 2014]. Chinese. Available from: <http://statis.moi.gov.tw/micst/stmain.jsp?sys=220&ym=9802&ymt=9905&kind=21&type=1&funid=c0910102&cycle=41&outmode=0&compmode=0&outkind=1&fldspc=0,2,&codspc=0,2,&cod10=1&rdm=0qod9aBu>
 13. Department of Statistics, Ministry of Education, Taiwan. [Statistics Inquiry: school attendance rate]. Taipei: Ministry of Education. [Accessed 12 Dec 2014]. Chinese. Available from: <https://stats.moe.gov.tw/qframe.aspx?qno=MgA3AA2>
 14. Parker AA, Staggs W, Dayan GH, Ortega-Sánchez IR, Rota PA, Lowe L, et al. Implications of a 2005 measles outbreak in Indiana for sustained elimination of measles in the United States. *N Engl J Med*. 2006;355(5):447-55. <http://dx.doi.org/10.1056/NEJMoao60775> PMID:16885548
 15. Andrews N, Tischer A, Siedler A, Pebody RG, Barbara C, Cotter S, et al. Towards elimination: measles susceptibility in Australia and 17 European countries. *Bull World Health Organ*. 2008;86(3):197-204. <http://dx.doi.org/10.2471/BLT.07.041129> PMID:18368206
 16. Centers for Disease Control and Prevention (CDC). Measles outbreaks and progress toward measles preelimination --- African region, 2009-2010. *MMWR Morb Mortal Wkly Rep*. 2011;60(12):374-8. PMID:21451448
 17. Hu X, Xiao S, Chen B, Sa Z. Gaps in the 2010 measles SIA coverage among migrant children in Beijing: evidence from a parental survey. *Vaccine*. 2012;30(39):5721-5. <http://dx.doi.org/10.1016/j.vaccine.2012.07.007> PMID:22819988
 18. Goodson JL, Chu SY, Rota PA, Moss WJ, Featherstone DA, Vijayaraghavan M, et al. Research priorities for global measles and rubella control and eradication. *Vaccine*. 2012;30(32):4709-16. <http://dx.doi.org/10.1016/j.vaccine.2012.04.058> PMID:22549089
 19. Chiu RK, Yen CC, Weng SW, Chi SP, Tsai CW, Pan PY. The survey study of user satisfaction for National Immunization Information System with continuous evolution. *The Journal of Taiwan Association for Medical Informatics*. 2005;14(2):51-78.
 20. Ministry of Health and Welfare (MOHW). Health Statistics in Taiwan, 2010. 28 Nov 2012. Taipei: MOHW; 2012. Available from: http://www.mohw.gov.tw/EN/Ministry/Statistic.aspx?f_list_no=474&fod_list_no=3506
 21. Organisation for Economic Co-operation and Development (OECD). Health at a Glance 2013: OECD Indicators. OECD Publishing; 2013; http://dx.doi.org/10.1787/health_glance-2013-en
 22. Sheridan SL, Lambert SB. Letter to the editor: Australian immunisation registers: established foundations and opportunities for improvement. *Euro Surveill*. 2012;17(21):pii=20177. PMID: 22687828
 23. De Wals P, Deceuninck G, Toth E, Boulianne N, Brunet D, Boucher RM, et al. Risk of Guillain-Barré syndrome following H1N1 influenza vaccination in Quebec. *JAMA*. 2012;308(2):175-81. <http://dx.doi.org/10.1001/jama.2012.7342> PMID:22782419
 24. Daley MF, Barrow J, Pearson K, Crane LA, Gao D, Stevenson JM, et al. Identification and recall of children with chronic medical conditions for influenza vaccination. *Pediatrics*. 2004;113(1 Pt 1):e26-33. <http://dx.doi.org/10.1542/peds.113.1.e26> PMID:14702491
 25. Johansen K, Lopalco PL, Giesecke J. Immunisation registers--important for vaccinated individuals, vaccinators and public health. *Euro Surveill*. 2012;17(16):20151. PMID:22551460
 26. Ministry of Justice, Taiwan. Personal Information Protection Act. Taipei: Ministry of Justice; 2012. Available from: <http://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?PCode=10050021>