National Communicable Disease Surveillance System: A review on Information and Organizational Structures in Developed Countries

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ABSTRACT

Introduction: To obtain necessary information for managing communicable diseases, different countries have developed national communicable diseases surveillance systems (NCDSS). Exploiting the lesson learned from the leading countries in development of surveillance systems provides the foundation for developing these systems in other countries. In this study, the information and organizational structure of NCDSS in developed countries were reviewed. Methods: The study reviewed publications founded on the organizational structure, content and data flow of NCDSS in the United States of America (USA), Australia and Germany that were published in English between 2000 and 2016. The publications were identified by searching the CINAHL, Science Direct, ProQuest, PubMed, Google Scholar databases and the related databases in selected countries. Results: Thirty-four studies were investigated. All of the reviewed countries have implemented the NCDSS. In majority of countries the department of health (DoH) is responsible for managing this system. The reviewed countries have created a minimum data set for reporting communicable diseases data and information. Conclusion: For developing NCDSS, establishing coordinator centers, setting the effective policies and procedures, providing appropriate communication infrastructures for data exchange and defining a communicable diseases minimum data set are essential.

Keywords: Communicable diseases, surveillance system, data content, data flow, organizational structure.

1. INTRODUCTION

Over the centuries, communicable diseases have always been as one of the main threats for human health. These diseases often spread quickly (1) and resulted in high mortalities (2, 3, 4). Between 2011 and 2014 respiratory infectious diseases, diarrhea, AIDS and malaria have constantly been on the top 10 causes of death worldwide (5, 6).

Effective management of communicable diseases requires developed systems which provide timely, comprehensive and updated information (7). At the end of the last century, many countries implemented NCDSS for the ongoing, systematic collection, analysis and interpretation of the communicable diseases data (8, 9). Surveillance systems should be capable of laying the foundation for effective controlling and managing of communicable diseases (10, 11). Some of these capabilities that have been identified by WHO are: the capability of providing key and supportive services of surveillance system, having the appropriate structure and high quality information (12, 13, 14, 15).

WHO specifically emphasizes on provision of timely, comprehensive and reliable data and information by surveillance systems and notes that effective management of data and information at different levels, is related to high quality data content and timely exchange of data with related organizations (16). Establishing effective communication among related organizations, centers, individuals and departments during the data generation and exchange process is of particular importance for timely and quick data exchange for communicable diseases.

A mechanism should be defined to release data for decision makers and policy-making centers (1, 17). Development of electronic system for collecting and reporting communicable diseases data provides timely exchange of such data (16). Many of developed countries have created a national communicable diseases surveillance system and saved
the collected data in a centralized data warehouse. In these countries, the ministry of health is directly in charge of coordinating and supporting this system. Different organizations at the local and state levels work with the ministry of health for data exchange (14).

In every country the creation and implementation of surveillance systems is essential for effective controlling and managing of communicable diseases (16, 17). Therefore, the awareness of the NCDSS structure in developed countries and using the experiences of these countries could pave the road for promotion of surveillance systems in other countries, especially in developing countries. Thus this research aims to review the organizational structure, data content and data flow of NCDSS in developed countries.

2. METHODS

Data were collected through search in CINAHL, Science Direct, ProQuest, PubMed and Google Scholar databases as well as the publications of the USA Center for Disease Control and Prevention, Germany’s Robert Koch Institute and Australian Department of Health and Ageing. The studies that described the NCDSS in terms of organizational structure, data content and flow in selected countries (USA, Australia and Germany) during 2000-2016 period and published in English were included in this study. The USA and Australia were selected for their progressive development in reporting and launching communicable diseases surveillance systems. They have employed such systems for almost a century (18,19). Germany was selected for the highest rate of information reporting to the European Surveillance System (TESSy) among European countries (20). The search terms included, but not restricted to, communicable diseases, surveillance system, data content, data flow, organizational structure, and developed countries. Thirty-four studies from the USA, Germany and Australia were retrieved used in the findings.

3. RESULTS

The Organizational Structure of Surveillance Systems in Selected Countries

There is a National Notifiable Diseases Surveillance System (NNDSS) in the US which saves the communicable diseases data and information received from across the country. This system encompasses reports on 172 diseases of which more than 57 of them are infectious.

Office of Infectious diseases (OID) as a division of Center for Diseases Control and Prevention (CDC) is tasked with managing communicable diseases and the NNDSS. The mission of the Office of Infectious Diseases is to lead, promote, and facilitate science, programs, and policies to reduce the burden of infectious diseases in the United States and globally (18, 21, 22, 23).

The Council of State and Territorial Epidemiologists (CSTE) is a leading center working with CDC. CSTE provides technical advice and assistance to partner organizations and to federal public health agencies such as the Centers for CDC. This council is responsible for creation and revise of notifiable conditions annual list (24, 25). CDC’s are working actively in all states and territories in the US and are tasked with leading and managing communicable diseases at these levels (Table 1) (26).

DHIS supports NNDSS by receiving, securing, processing, and providing nationally notifiable infectious diseases data to disease-specific CDC programs (27, 28). National Notifiable Disease Surveillance system (NNDSS) of Australia was launched in 1991 as the primary surveillance system of this country. The Australian Government manages NNDSS under the auspices of the Communicable Diseases Network Australia (CDNA) and coordinates the surveillance of 69 infectious diseases and conditions were nationally notifiable (29, 30, 31).

Communicable disease surveillance in Australia operates at the national, state and local levels. Department of Health and Ageing (DoHA) is in charge of coordinating a response to national or multi-jurisdictional outbreaks; detecting outbreaks and identifying national trends; providing guidance for policy development and resource allocation at the national level.

Office of Health Protection as a division of Australian DoHA holds key roles as a coordinator of national action in response to communicable disease outbreaks, and as a leader in the development of best practice guidelines and national public health policy. There is a Health Protection Policy Branch (HPPB) in DoHA which provides national leading, policy-making, analysis, coordination and communications, formulation of care strategies and responses to the threats posed by emerging infectious diseases (32, 33, 34, 35).

The Australian Health Protection Principal Committee (AHPPC) as one of the several active committees of

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| Component of organizational structure | Australia | United States of America | Germany |
|---------------------------------------|-----------|---------------------------|---------|
| National Communicable diseases surveillance system | Department of Health and Ageing | Department of Health and Human Services | Robert Koch Institute |
| Leading organizations at national level | Communicable Diseases Network Australia (CDNA) and Public Health Laboratory Network (PHLN) | Center for Diseases Control and Prevention (CDC) | Department of Epidemiology and Health Monitoring |
| Policy-Maker organizations | Council of State and Territorial Epidemiologists, in collaboration with Centers for Disease Control and Prevention | | |
| Active organization in data gathering | Public health units | | |
| Responsible centers for information management | Surveillance and Epidemiology Section | | |

Table 1. Organizational Structure of National Communicable Disease Surveillance System in selected countries
HPPB provides overarching national leadership on emerging health threats related to communicable diseases (34). The AHPPC reports to the Australian Health Minister’s Advisory Council (AHMAC), an Australian Governments’ Standing Council on Health (SGoH). Reporting to AHPPC are six Standing Committees with a key role in national health protection issues. The two networks with the broadest scope to oversight communicable disease control are Communicable Disease Network Australia (CDNA) and Public Health Laboratory Network (PHLNN). All public health units, territories and state health centers and centers affiliated with DHOA are involved in the management process of communicable diseases. Also, Surveillance and Epidemiology Section of DHOA has been tasked with information and technical supports (32).

Since its inception in 1981, Robert Koch Institute (RKI) has been assigned to managing infectious diseases in Germany. According to Infektionsschutzgesetz Act (IfSG), RKI as one of the leading health institutes of Germany is responsible for collection, analysis and interpretation of epidemiological data of infectious diseases forwarded from across Germany (Table I) (36, 37, 38).

In 2001, the Robert-Koch-Institute (RKI) implemented a new electronic surveillance system for infectious disease outbreaks (SurvNet) in all administrative levels of the German Public Health System. This system was primarily intended to assure the exchange of data of communicable diseases among healthcare institutions at local, state and federal levels. This system was adopted in 2006 by 431 local health departments, the 16 state health departments and RKI itself (39, 40).

In Germany, the data surveillance and data management units which have been defined as divisions of RKI’s department of epidemiologic of infectious diseases are responsible for informational and technical supports of SurvNet@RKI. In compliance with Infektionsschutzgesetz Act, The surveillance unit has been tasked with implementing the reporting system. Data Management Unit is responsible for designing, developing and managing IT projects in relation to infectious diseases (Table I) (41, 42).

The Information Structure of Communicable Diseases Surveillance Systems in Selected Countries

Regarding data content, the results revealed that core data which include demographic, treatment, laboratory, vaccination, epidemiologic and pharmaceutical data are gathered and recorded in all of the reviewed countries (43, 44, 45).

In the US, demographic, treatment, laboratory and epidemiologic data are reported to local health departments and then state centers from their sources of origin (surgeons’ offices, hospitals, dentist’s offices and etc.). Then data are sent to CDC for further action and analyses. Reporting of notifiable diseases is mandated only at state level. National Electronic Diseases Surveillance System (NEDSS) is tasked is tasked with e-transfer of data of the surveillance system from the healthcare sector to the public health sector. In fact it is assigned to transfer the data to NNDSS (46, 47, 48, 49).

In the US, in collaboration with NNDSS, the DHIS prepares a brief report that contains the information and the last status of communicable and non-communicable diseases to be published in the mortality and morbidity weekly reports (MMWR) (Table 2) (27).

In Australia, demographic, treatment, personal and family information as well as microbiological data are forwarded on a daily basis from their sources of origin to local health centers and then to state or regional centers. In the next stage, the authorities send their reports to the national level (50, 51, 52).

In DoHA, the unit for separation of personal specifications as a division of office of epidemiologic of communicable diseases sorts out the reports planned to be forwarded to the Office for Aging and the Aged Care and then posts them on Australia’s quarterly journal for Communicable Diseases Intelligence (Table 2) (30).

In Germany, demographic, treatment, vaccination, diagnostic and risk factors are electronically forwarded to state SurvNet@RKI as the set of minimum data from their sources of origin i.e. public and private hospitals, laboratories and other healthcare providers. Then the data are sent to federal SurvNet@RKI for further action and analyses (Table 2) (6, 53).

4. DISCUSSION

The results showed that the reviewed countries have developed their electronic systems for storing data of communicable diseases at a national level (23, 30, 39). There is world-
wide consensus on the need for improvement and upgrade the current surveillance system relative to emerging infectious diseases. Electronic communicable diseases surveillance system can speed up the reporting process of diseases; facilitate data aggregation and managing bulk of data (54, 55).

In spite of advantages of electronic reporting systems and despite the fact that national communicable diseases surveillance systems have been in place, the results revealed that the electronic surveillance systems of the studied countries are far from the desirable state at both local and state levels.

The experience and profiles of developed countries indicate that such systems could not be initiated so long as the proper infrastructures are not implemented for data exchanges across different centers (23, 31, 37, 38).

Poor communication among the centers and organizations related to management of communicable diseases at different levels was one of the drawbacks detected in the studies countries (10, 14, 16). In his study, Tucker suggests that defining a certain center for leading and coordinating the entities involved in control and prevention of communicable diseases is one of the most important requirements for launching communicable diseases surveillance systems (56).

In his review study of surveillance systems, Dato suggests that a number of centers should be set up at different levels for feeding information and technical information into the communicable diseases surveillance system of. These centers must be assigned to management and assessment of surveillance system data, constant analysis of communicable diseases data, defining criteria for inclusion of diseases into the surveillance system and dissemination of information about the diseases (10, 57).

Relative satisfaction was expressed regarding the surveillance systems in the studied countries. A number of issues such as shortages of human resources and underfunding, poor coordination among entities involved at different levels, poor informatics skills of the surveillance staff, failure to implement proper standards for data exchange and security and failure of higher levels to give feedbacks to lower tiers had prevented the systems from winning the full satisfaction of the clients (22, 29, 36). The results revealed that the minimum data set, i.e. demographic, laboratory, clinical and vaccination data are recorded and reported in the studies countries (43, 46, 49, 52). In these countries, data of most communicable diseases are first sent to local or territorial health departments which have them forwarded to national surveillance systems. Therefore, making sure that the collected data are consistent, comprehensive and comparable at different levels is a critical point (29, 36). European center for Disease control and prevention has defined a list of essential data for European countries for reporting cases of communicable diseases which include epidemiological, demographic, clinical, laboratory and risk factors (58).

WHO has made it clear in its manual of monitoring and assessment of communicable diseases surveillance and reporting that every country has the task of collecting essential data such as demographic, clinical, risk factors, geographical and epidemiological data and submit cumulative reports to that organization about the rate of incidence and outbreaks of such diseases, their fatality rates and mortality statistics of each disease (12).

Data source is a place where initial disease information is collected and forwarded to public health centers (58). Laboratory, general practitioners’ offices and hospitals are known as conventional sources of reporting cases of communicable diseases (59). The results of this study revealed that data sources at least included Laboratory, general practitioners’ offices and hospitals and healthcare providers (41, 47, 49). Every organization, center and interested entity that is involved in the process of recording, diagnosing, treatment and dissemination of communicable diseases data must establish close communication with surveillance systems. Weak contribution of the private sector in the management of communicable diseases was one of the challenges in the studied countries (15, 18).

5. CONCLUSION

In developed countries, control and management of communicable diseases have departed from paper-based systems and moved towards electronic systems. For this, a large number of developed countries have started implementing national electronic surveillance systems. However, they are far from satisfactory initiation of such electronic system at lower levels. Using the experience of these countries could give other countries a shortcut to implementing effective surveillance system with the ultimate goal of successful management of communicable diseases.

REFERENCES

1. Abat C, ClauDET H, Rolain JM, Colson P, Raoult D. Traditional and syndromic surveillance of infectious diseases and pathogens. International Journal of Infectious Diseases. 2016; 48: 22-8.
2. Abrahams J. Disaster Risk Management for Health communicable diseases. Developed by the World Health Organization. United Kingdom Health Protection Agency and partners. Global Platform 2011.
3. Coker R, Atun R, McKee M. Health Systems and the Challenge of Communicable Disease Experiences from Europe and Latin America. European Observatory on Health Systems and Policies Series. 2008.
4. Flahault A, Schlipköter U. Communicable Diseases: Achievements and Challenges for Public Health. Public Health Reviews. 2010; 32(1): 90-119.
5. Bhutta ZA, Sommerfeld J, Lassi ZS, Salam RA and Das JK. Global burden, distribution, and interventions for infectious diseases of poverty. 2014; 3(21).
6. European Centre for Disease Prevention and Control. Annual
Epidemiological Report on Communicable Disease in Europe; Report on the State of Communicable Disease in the EU and EEA/EFTA Countries. Stockholm, European Centre for Disease Prevention and Control. 2008.

7. Aqil A, Lippeveld T, and Hozumi D. PRISM Framework: a paradigm shift for designing, strengthening and evaluating routine health information systems. Health Policy and Planning. 2009; 24: 217-28.

8. Eldin SS. The Disease and outbreaks Surveillance System at the National Level and the State Capital: A Descriptive Study. Faculty of Medicine; Institute of Health and Society; Department of General Practice and Community Medicine; University of Oslo. 2011.

9. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Infectious disease surveillance framework 2014-2019: Better data for better action. Toronto. ON: Queen’s Printer for Ontario. 2014.

10. Sahal N, Reintjes R, Aro AR. Communicable diseases surveillance lessons learned from developed and developing countries: Literature review. Scandinavian Journal of Public Health. 2009; N1: 1-14.

11. WHO. Human and animal brucellosis epidemiological surveillance in the MZCP Countries. Report of a WHO/MZCP Workshop Damascus, Syrian Arab Republic. 1998. Retrieved: http://www.mzcpzoonoses.gr/pdfen/Brucellosis.pdf, 2007.

12. WHO. Overview of the WHO framework for monitoring and evaluating surveillance and response systems for communicable diseases. WHO. Geneva, 2004.

13. Heymann DL. Control, elimination, eradication and the re-emergence of infectious diseases: getting the message right. Retrieved from Bulletin of the WHO. 2006; 84(2): 82.

14. Janati A, HosseinyM, Gouya MM, Moradi GHA, Ghaderi E. Communicable Disease Reporting Systems in the World: A Systematic Review Article. Iran J Public Health. 2015; 44(11): 1453-65.

15. Sahal NH. Assessment of communicable diseases surveillance system in Khartoum state, Sudan 2005-2007. [PhD Thesis]. Faculty of Health Sciences University of Southern Denmark, Denmark. 2011.

16. Chandrasekar K. Use of Information Communication Technology in communicable disease surveillance Sri Lanka Journal of Bio-Medical Informatics. 2011; 2(2): 41-52.

17. Kessler W, Salerno SM. Infectious Disease Detection and Control in the Developing World. Department of Commerce; National Technical Information Service, 2014.

18. Center for diseases control and prevention. History and background of National Notifiable Diseases Surveillance System (NNDSS). 2015.

19. Department of Health. Office of Health Protection. Communicable diseases information, using internet search queries for infectious, 2016.

20. Milinovich GJ, Avril SM, Clements AC, Brownstein JS. et al. Disease surveillance: screening diseases for suitability. Milinovich et al. BMC Infectious Diseases. 2014; 14: 690.

21. Tropp T, Haney G, Cocoros N, Cranston K, Demaria Jr A. Infectious disease surveillance in the 21st century: an integrated web-based surveillance and case management system. Public Health Reports. 2014; 129(2): 132-8.

22. Council of State and Territorial Epidemiologists. Review of and Recommendations for the national Notifiable Disease Surveillance System: A State and Local Health Department Perspective. 2013.

23. Centers for Surveillance, Epidemiology, and Laboratory Service. National Notifiable Disease Surveillance System (NNDSS). 2015.

24. National Electronic Disease Surveillance System Working Group. National Electronic Disease Surveillance System (NEDSS); a standards-based approach to connect public health and clinical medicine. J Public Health Manag Pract. 2001; 7(6): 43-50.

25. Centers for Disease Control and Prevention (CDC). State electronic disease surveillance systems—United States, 2007 and 2010. MMWR Morb Mortal Wkly Rep. 2011; 60(41): 1421-3.

26. CDC. National Electronic Disease Surveillance System. Atlanta, GA: US Department of Health and Human Services, CDC. 2011. Retrieved: http://www.cdc.gov/phinfo/tools/neds/index.html.

27. Centers for Disease Control and Prevention. Division of Health Informatics and Surveillance. DHIS Fact Sheets.2016. Retrieved: https://www.cdc.gov/ophls/ciels/dhis/fact-sheets.html

28. Centers for Disease Control and Prevention. Division of Health Informatics and Surveillance. DHIS Overview. 2016. Retrieved: https://www.cdc.gov/ophls/ciels/dhis/overview.html

29. Williams S, Selvey C, Huppatz C. System Overview of Communicable Disease Control in Australia 2012. Australian Government Department of Health. 2012.

30. Australian Government Department of Health and Ageing (DoHA). Introduction to the National Notifiable Diseases Surveillance System. 2015.

31. NNDSS Annual Report Working Group. Australia’s notifiable disease status, 2014: Annual report of the National Notifiable Diseases Surveillance System. CDI. 2016; 40 (1).

32. Miller M, Roche P, Spencer J, Deeble M. Evaluation of Australia’s National Notifiable Disease Surveillance System. Commun Dis Intell Q Rep. 2004; 28(3): 311-23.

33. Australian Government Department of Health and Ageing. Towards a Communicable Disease Control Framework for Australia; a Discussion Paper from the Communicable Disease Network Australia. 2013.

34. Australian Government Department of Health and Ageing. National Framework for Communicable Disease Control. © Commonwealth of Australia. 2014.

35. Australian Government Department of Health and Ageing. The Health Protection Policy Branch. What we do. 2016.

36. Robert Koch Institute. Department for Infectious Disease Epidemiology. Evaluation Report – Public Version For the period of 1 January 2009 – 30 September 2012. December 2012.

37. Robert Koch Institute. 125 Years Robert Koch Institute; the Danish National Infectious Disease Surveillance and Control. 2011. Retrieved: http://www.rki.de/2011. Retrieved: http://www.rki.de/2011.

38. Centers for Disease Control and Prevention. Division of Health Informatics and Surveillance. DHIS Overview. 2016. Retrieved: https://www.cdc.gov/ophls/ciels/dhis/overview.html

39. Faensen D, Claus H, Benzler J, Ammon, A, Pfoch T, Breuer T, et al. SurvNet@RKI – a multistate electronic reporting system for communicable diseases. Euro Surveill. 2006; 11(4): 100-3.

40. Krause G, Altmann D, Faensen D, Porten K, Benzler J, et al.. SurvNet Electronic Surveillance System for Infectious Disease Outbreaks, Germany. Emerging Infectious.2007; 13(10):1548-155.

41. Robert Koch Institute. Unit 31: Data Management. Re-
National Communicable Disease Surveillance System: A review on Information and Organizational Structures in Developed Countries

42. Robert Koch Institute. Unit 32: Surveillance. URL: http://www.rki.de/EN/Content/Institute/DepartmentsUnits/InfDiseaseEpidem/Div31/div31_node.html

43. Vogt RL, Spittle R, Cronquist A, Patnaik JL. Evaluation of the Timeliness and Completeness of a Web-based Notifiable Disease Reporting System by a Local Health Department. J Public Health ManagPract, 2006; 12(6): 540-4.

44. Faensen D, Krause G. SurvStat@RKI - a web-based solution to query surveillance data in Germany. Euro Surveill [Seri Internet]. 2004; 8(22): 100-3.

45. Communicable Disease Intelligence. Surveillance systems reported in Communicable Diseases Intelligence. CDI 2016; 40(1).

46. Center for diseases control and prevention. What Data Users Should Know About the National Notifiable Diseases Surveillance System? 2001.

47. Samoff E, MT F, AT F, Waller AE, MacDonald PDM. Improvements in Timeliness Resulting from Implementation of Electronic Laboratory Reporting and an Electronic Disease Surveillance System. Public Health Reps. 2013; 128(5): 393-8.

48. Kite Powell A, Hamilton JJ, Hopkins RS, DePasquale JM. Potential Effects of Electronic Laboratory Reporting on Improving Timeliness of Infectious Disease. MMWR. 2008; 57(49): 1325-8.

49. Timothy J, Doyle M, Kathleen Glynn, Samuel L, Grosseclose Completeness of Notifiable Infectious Disease Reporting in the United States: An Analytical Literature Review. American Journal of Epidemiology 2002; 155(9): 866-74.

50. Australian Government Department of Health and Ageing. About Communicable Diseases Network Australia; 2015.Retrieved: http://www.health.gov.au/internet/main/publishing.nsf/content/cda-cdna-cdna.htm

51. Rohart F, Milinovich GJ, Avril MR, Lê Cao1 KA, Tong SH, Hu W. Disease surveillance based on Internet-based linear models: an Australian case study of previously unmolded infection diseases. Scientific Reports | 6:38522 |, doi: 10.1038/srep38522

52. National Health and Medical Research Council. Australian Guidelines for the Prevention and Control of Infection in Healthcare. Australian Commission on Safety and Quality in Healthcare, 2010.

53. Krause G, Ropers G, Stark K. Notifiable disease surveillance and practicing physicians. Emerge Infect Dis. 2005; 11(3): 242-6.

54. Rolffhamre P, Jansson A, Arneborn M, Ekdahl K. SmiNet-2: description of an internet-based surveillance system for communicable diseases in Sweden. Euro Surveill.2006; 11(5): 103-7.

55. Ward M, Brandsema P, van Straten E, Bosman A. Electronic reporting improves timeliness and completeness of infectious disease notification. Euro Surveill. 2005; 10(1): 27-30.

56. Thacker SB, Lee LM. The Cornerstone of Public Health Practice: Public Health Surveillance. Office of Surveillance, Epidemiology and Laboratory Services, CDC. 2012.

57. Dato V, et al. How Outbreaks of Infectious Disease are detected: A Review of Surveillance Systems and Outbreaks. Public Health Reports. 2004; 119; 464-71.

58. European Centre for Disease Prevention and Control. Data quality monitoring and surveillance system evaluation - A handbook of methods and applications. Stockholm; ECDC. 2014.

59. Vavalle EE. An evaluation of mandatory communicable disease reporting in North Carolina. [Ph.D. Thesis]. University of North Carolina, USA, 2010.