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Analysis of Integrated Information Systems in Community-based and School-based Public Health Surveillance

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Abstract

BACKGROUND: The involvement of the community in supporting health programs requires an integrated information system. Public health registers obtained by the community means some data is collected repeatedly in different formats or leads to data redundancy.

AIM: This research aims to analyze and design an integrated information system model of current community-based and school-based public health surveillance based on a system development life cycle approach.

METHODS: Data analysis is carried out using content analysis.

RESULTS: The results show that entities involved in the system include health cadres in Posyandu (an integrated health post for maternal and child health), Posbindu (an integrated development post of noncommunicable disease), and school health services. The necessary data include data on vital characteristics, maternal and child health, the risk factors of both communicable and noncommunicable diseases, students' illness complaints, clean and healthy living behavior, mortality, and environmental health. Information obtained includes the health status of an individual, planning on pregnancy and labor, antenatal care visits, stunting data, immunization status, students' illness complaints, the number of accidents, larva-free rate, and mortality rate. Information from the system is reported to public health centers, the district health office, and district education office.

CONCLUSION: The output of the system is useful to complement the recording and reporting of data from health facilities.

Introduction

Indonesia is struggling to face the triple burden of disease as a result of the increasing prevalence of noncommunicable diseases (e.g., diabetes mellitus, hypertension, and stroke) and incidences of re-emerging and new-emerging diseases (e.g., SARS, avian influenza, and swine influenza) while the infectious diseases (e.g., tuberculosis [TB] and HIV/AIDS) are still on the rise [1]. For instance, according to the latest national survey in 2018, the prevalence of diabetes mellitus among adults of 15 years and above reached the number of 10.9% [2]. Based on Global TB Report, the incidence of TB at the same year reached 570,289 cases [3]. Indonesia is also considered to be one of six countries for highly pathogenic avian influenza H5N1 [4]. To respond to this challenge, the government of Indonesia has initiated the involvement of health information systems. However, these systems remain disease-specific, fragmented, and unconsolidated. For example, the HIV and AIDS information system was implemented to integrate a HIV and AIDS recording and reporting system [5], the integrated TB information system [6], and registers for maternal and child health [7].

Health surveillance is defined as a continuous, systematic collection, analysis, and interpretation of health-related data that are essential to the planning, implementation, and evaluation of health practice. Health surveillance plays an important role in providing evidence to facilitate the prevention and control of diseases [8]. Health surveillance is one of the subsystems in the national health system of Indonesia that is regulated by the Presidential Regulation of the Republic of Indonesia Number 72 of the year 2012 on the National Health System. As one of the data sources that can be conducted through both active and passive surveillance, the involvement of community members is important to improve data quality.

The involvement of the community in health surveillance is reflected by the role of health cadres through *Posyandu* (an integrated health post for maternal and child health), *Posbindu* (an integrated development post of noncommunicable disease), and school health services. Health programs carried out by the community are expected to be comprehensive and continuous in accordance with the continuum of care. The continuum of care is a strategic approach in looking at health problems in a comprehensive range from the

birth to death of an individual [9]. This approach helps health-care providers meet the needs of an individual through life's transition considering that the individual may be more vulnerable and susceptible to health problems during discontinuities or gaps in care [10]. For instance, it is evidenced by Damayanti *et al*. [11] that maternal health status can be used as a risk factor predictor for the mother and the baby she conceived and bore. This confirms that the relationships between mothers and babies cannot be separated in terms of the need for health services.

One of the efforts that can be made to effectively sustain the health programs is to integrate the program. Integration refers to the act of adoption or assimilation of smaller health interventions into a single health system that functions as one [12]. Suter *et al*. [13] stated that information systems are one of the key principles in the success of integrated health systems. Information system integration can be carried out through developing current information systems in the context of data management and usage. An integrated information system connects users, providers, and various parties related to their health problems. This study aims to develop an integrated information system model of school-based and community-based public health surveillance.

Design and Methods

The result of this study is part of a multiyear sequencing study that was conducted from February 2018 to November 2020 through the integration of recording and reporting systems in community-based and school-based surveillance. The conceptual framework is based on the continuum of care approach [14] and the system approach [9]. Continuum of care refers to the continuity of care from the birth to death of an individual. The research conceptual framework is presented in Figure 1.

This research is operational research in developing current health information systems with variables including data types, data sources, data collection, data analysis, information dissemination, and epidemiological information based on a system development life cycle (SDLC) approach. This approach includes system analysis, system design, system implementation, and system maintenance. The SDLC stages performed in this study were system analysis and system design as part of the system approach. System analysis describes the ongoing surveillance information system based on its components, namely input, process, and output, to identify and evaluate problems, opportunities, obstacles that may occur, and expected needs to achieve improvements, especially data and information. These stages were conducted to identify the data and information required by the integrated surveillance information system. System design is further conducted to define functional needs, prepare the implementation design, describe how the system is developed, and configure both the software and hardware of the system, by developing an application prototype through data flow diagrams (DFD). The system that had been designed is further tested and installed at the stage of system implementation and occasionally maintained through security operations and administration, operational assurance, audits, and monitoring [15].

The city of Surabaya was chosen to be the research location due to the high prevalence of health problems that occurred. The research information is obtained from surveillance staff at the Surabaya City Health Office, school healthcare unit providers, and health cadres in *Posyandu* and *Posbindu*. Data collection is carried out by in-depth interviews, documentary studies, and focus group discussions. The documentary studies are conducted on the recording and reporting formats used in the ongoing school-based and community-based surveillance. The information gathered from in-depth interviews and documentary studies is then discussed in the focus group discussion to identify the necessary data and information in attaining information system integration in school-based and community-based surveillance. Observation sheets and focus group discussion guidelines are used to conduct the documentary studies and focus group discussions. Data collected from in-depth interviews, documentary studies, and focus group discussions are analyzed using content analysis. The collected data are classified by themes or aspects to be presented in the form of narratives, charts, and tables.

Results

Our findings show that community has participated in supporting health programs in Indonesia that includes health surveillance and disease control and prevention. This is reflected by the involvement of the community in the recording and reporting of health data. It is evidenced by studies in several countries that suggest the importance of the role of health cadres in handling health problems at a household level and had been documented both in developed countries such as the United States and developing countries such as Brazil, Iran, Pakistan, and sub-Saharan Africa [16], [17]. Teachers, on the other hand, play an important role as school health service stakeholders in preventing and controlling the diseases that are often found in school-aged children (i.e., soil-transmitted helminthiasis, childhood obesity, stunting, and thinness). Teachers' involvement in recording students' attendance is also of great importance as it is one simple plausible

indicator of health evidence in school-aged children. Student absence from school can provide an early warning of some outbreaks [18]. For example, a study in China reported that varicella, mumps, and influenza-like outbreaks were successfully identified through the report of student absences from school [19].

Health cadres, teachers, and caretakers in the communities, schools, and childcare centers are also able to conduct syndromic surveillance that refers to the use of pre-diagnostic health indicators to enable timely detection and investigation of potential infectious disease outbreaks. It can be considered as an additional approach to routine public health surveillance by allowing early identification of clusters of diseases before the official data are available. Data regarding disease symptoms that have been collected by syndromic surveillance are considered to be one of the important preventive efforts [20]. Research in Malawi showed that the Malawi community case management system, a policy aimed at a community-level treatment program for malaria, diarrhea, and pneumonia for children, is a promising strategy to increase the coverage of care for sick children. Although there is still much room for improvement, especially in the assessment and treatment given to the children with suspected pneumonia, identification and referral of sick children with danger signs, health surveillance assistants provide initial treatment for sick children at a level of quality that is like the treatments provided in first-rate health facilities in Malawi. Syndromic surveillance performed in China of symptoms like fever (a condition in which the body temperature rises to more than 37.5°C or self-disclosure of fever), diarrhea (≥ three or more defecations per day), jaundice (a yellow tinge to the skin and whites of the eyes, dark urine, and itchiness), a rash (abnormal skin changes, including pruritus and pain), inflammation of the conjunctiva (reddened, swollen, or burning eyes), inflammation of the parotid gland (swelling on the rear side of the earlobe accompanied by fever and local pain when opening the mouth or chewing), and vomiting accompanied by headache and abdominal pain has the potential to enhance the capacities for early detection of disease outbreaks. Other research conducted by Wahyuni and Artanti in 2013 with suspected TB can be more effective by training the health cadres to perform the syndromic surveillance [21].

The involvement of the community and schools in the surveillance system must be facilitated with a practical, efficient, and interoperable system. Developing an integrated information system could be the key to increasing communication and information sharing across all levels of care from a community level to mainstream healthcare providers [22]. Analyzing and designing the system are important stages in the development of an integrated information system.

System analysis

This research found that fragmented surveillance systems have caused many registers or recording and reporting formats to produce data that are collected repeatedly in different formats or what is commonly called data redundancy. Data redundancy may cause costs to overrun, an increase in workload due to the repetition of data recording and reporting, and inconsistencies. Data redundancy occurs in the characteristics of the target population (mother, infant, and child), risk factors for pregnancy, childbirth, and postpartum, and types of services including types of immunization for children. Thus, the integration of current information systems may be advantageous to minimize unintentional data redundancy cases.

The implementation of this research model is based on the continuum of care that refers to the continuity of care of an individual throughout the major stages of their life cycle. Data collection is carried out during pregnancy, infancy, growth and development, at school-age, through health risk behaviors, reproductive years, and mortality. It is collected by health cadres who are in the system input entities that include *Posyandu*, *Posbindu*, and schools. Reports are submitted to the output entities, namely, the public health centers, district health and education offices.

Table 1 shows that the efforts to reach a continuity of care are conducted in various health programs. The community and schools play significant roles in every health program through *Posyandu*, *Posbindu*, and schools, including in recording and reporting health data from the stage of pregnancy until mortality. Our finding is consistent with earlier research conducted by Saepudin in 2017 that stated *Posyandu* has become a public health information center that leads to the understanding of the health needs required to provide the right care for mothers and children [23]. *Posbindu*, which is defined as the manifestation of the involvement of the community in early detection and monitoring of main noncommunicable diseases in integrated, routine, and

Table 1: System implementation methods based on continuum of care

Period	Pregnancy	Infancy	Growth and development	School age	Health risk behaviors	Reproductive age	Mortality
Data collector	All health cadres	*Posyandu* cadres	*Posyandu* cadres	*Posbindu* cadres, teachers	*Posbindu* cadres, teachers	*Posyandu* cadres	All health cadres
Location	Community, *Posyandu*	*Posyandu*	*Posyandu*	*Posbindu*, schools	*Posbindu,* schools	*Posyandu*	Community
Time	Incidental and routine on *Posyandu*	Routine on *Posyandu*	Routine on *Posyandu*	Incidental and routine on *Posyandu* or school health services activities	Incidental and routine on *Posyandu* or school health services activities	Routine on *Posyandu*	Incidental

periodic manners [24], also has a great significance in conducting prevention activities. This may be through health promotion, screening, and monitoring of the risk factors of noncommunicable diseases along with detecting the cases as early as possible to provide immediate treatment [25].

System design

The results obtained from the system analysis will be the material for the next stage of system development, namely, the design of the system. System design is a stage to describe the formation of a system and to configure the components of both system hardware and software. Context diagrams and DFD are used to describe the system models. The context diagram is used to describe the relationships between entities involved in the system. The description of the data and information flow in the system is demonstrated by the data flow diagram. The context diagram is shown in Figure 2.

An integrated health information system may improve the effectiveness and efficiency of health services through better management at all levels of the service [26]. Furthermore, allowing different providers, organizations, and sectors to communicate with each other that can be achieved by integrating health information systems, is necessary to identify and provide responses to health and well-being related dimensions throughout an individual's lifespan in all health-care settings. Faridah *et al*. Click or tap here to enter text. stated that an integrated health information system is required in the planning and implementation of health interventions to promote a better health system by helping the stakeholders to assess the health needs of the population and evaluating the effectiveness and efficiency of health programs [27].

Integrating the efforts of the entities to collect, process, report, and use health information requires the development of integrated health information systems for the community through *Posyandu* and *Posbindu* cadres and school health services units. Data that had been collected will be validated by schools and public health centers to be reported to District Education Office and District Health Office. The availability of reliable and timely health information from the input entities could allow the district education and health offices as the policymakers to come to decisions that are evidence-based and strategic. The flow of information through the system is described in Figure 3.

Data generated from input entities include data on vital characteristics, birth, growth and development of the children, data on school-aged children, health behavior, maternal health and the population at reproductive age, mortality, and all supporting data. Data on birth, growth and development of the children include characteristics, growth and development of the infant, completion of basic immunization, and adverse events following immunization (AEFI) on infants. Data on school-aged children include illness complaints reported by the students, completion of basic immunization, AEFI, and school attendance of the students. Data on health behavior include data on clean and healthy living behavior and non-communicable diseases-related risk behaviors. Data on maternal health and the population at reproductive age include family and pregnancy planning, characteristics of pregnant women, completion of antenatal care visits, labor, puerperium, and family planning. Data on mortality record the time, place, and cause of mortality. Data are compiled in a recording and reporting format that is integrated into a school-based and community-based public health surveillance information system model.

The data collected will be processed to produce the following information: The health status of the community both for the individual and as a

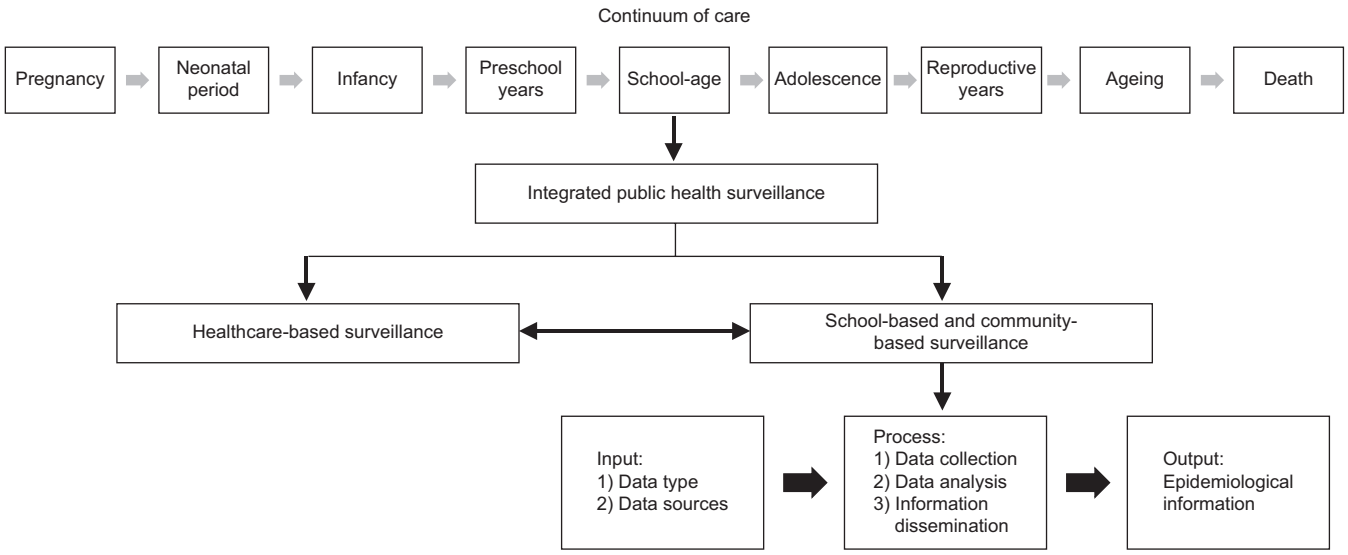

Figure 1: Conceptual framework

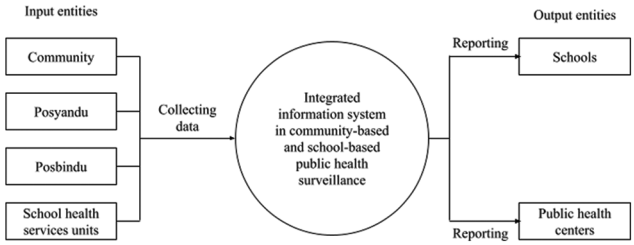

Figure 2: Context diagram in integrated health information systems in community-based and school-based public health surveillance

family; the number of high-risk pregnant women; the number of antenatal care visits; the number of babies with low birth weight; the number of infants who have not completed basic immunization; the number of infants and mortality; the number of incidences of adverse effects following basic immunizations; the number of illness complaints reported by students; the frequency and duration of absences of the students due to the health problems they may experience; the immunization status of the students; the number of incidences of adverse effects following immunization among students; descriptions of behavioral health among students; the proportion of noncommunicable disease-related risk factors; the coverage of risk factors of the population in an area; the number of accidents; larva-free rates; and descriptions of home and school environments. These epidemiological data can be utilized to improve the prevention of and early detection efforts to reduce the risk of the possibilities of several diseases' occurrence. For example, data on larva-free rates and descriptions of the home and school environments are important to understand the modes of transmission and to support the decision-making of an action plan for handling dengue fever effectively and efficiently [28].

Santoso *et al*. stated that health promotion and disease prevention efforts can be carried out through continuous and systematic studies of various types of diseases, especially those with the potential for outbreaks by conducting disease surveillance, analyzing the vulnerability of the community (e.g., immunization coverage), the environment, and other data in the epidemiological surveillance network that are developed through the health information system [29] stated that health promotion and disease prevention efforts can be carried out through continuous and systematic studies of various types of diseases, especially those with the potential for outbreaks by conducting disease surveillance, analyzing the vulnerability of the community (e.g., immunization coverage), the environment, and other data in the epidemiological surveillance network that are developed through the health information system. Schools are one of the strategic places to conduct public health surveillance as they can facilitate the outreach of health programs to school-age children that are considered to be a vulnerable population [30]. Research conducted in Ethiopia showed that food insecurity has been shown to be a determinant of student absence [31]. Other research in Indonesia found an outbreak of Hepatitis A in one of the high schools in Lamongan Regency by identifying the risk factors; these included shared utensils with the infected person, poor personal hygiene habits, poor sanitation, lack of hygiene and sanitation facilities, poor food hygiene management, and inadequate sources of clean and hygienic water [32].

Some innovative principles of public health surveillance had been introduced, including the use of cloud-based, electronic data collection and management and the use of case-based reports within the consultation. These features are hypothesized to bring several advantages such as the use of clinical decision support for diseases' diagnosis and management, data standardization and coding, provision of timely and reliable analysis and reporting and implementation that is cost-effective [33]. This is in accordance with Francois and Obisike [34] who said that technological developments have contributed significantly to improving the data quality and simplifying health information management activities so that health data management can be carried out more effectively and efficiently.

Successful information flow requires ensuring that information be recorded electronically, managed, governed, regulated, linked through a master index, and be made available to users through one or more interconnected software applications [35] as conveyed by WHO Global Observatory for eHealth [36] that an electronic health information system must be built to facilitate data exchange. With the existence of a health information system that provides access in digital format, it is expected that health workers can easily track patients' data over time, identify patients who are scheduled for preventive visits and screenings, and enhance the overall quality of patient care provided by the practice [37]. Health information that is carried out in an integrated manner can help health workers in providing better health services [38]. This is supported by the research of Kiberu *et al*. [39] that stated that the application of systems and the use of technology is very important to support health information management activities.

Technology that continues to develop may increase the potential of an integrated health information system to enhance the early screening and diagnostics of diseases that leads to cost reduction and efficiency for the health services of both noncommunicable and communicable diseases [40]. The application of a health information system through a website-based application is used to make it easier to provide access to health information [41]. The existence of a technology-based health information system also helps to reduce workload, paper usage (becoming paperless), and supports decision-making for health service providers [42].

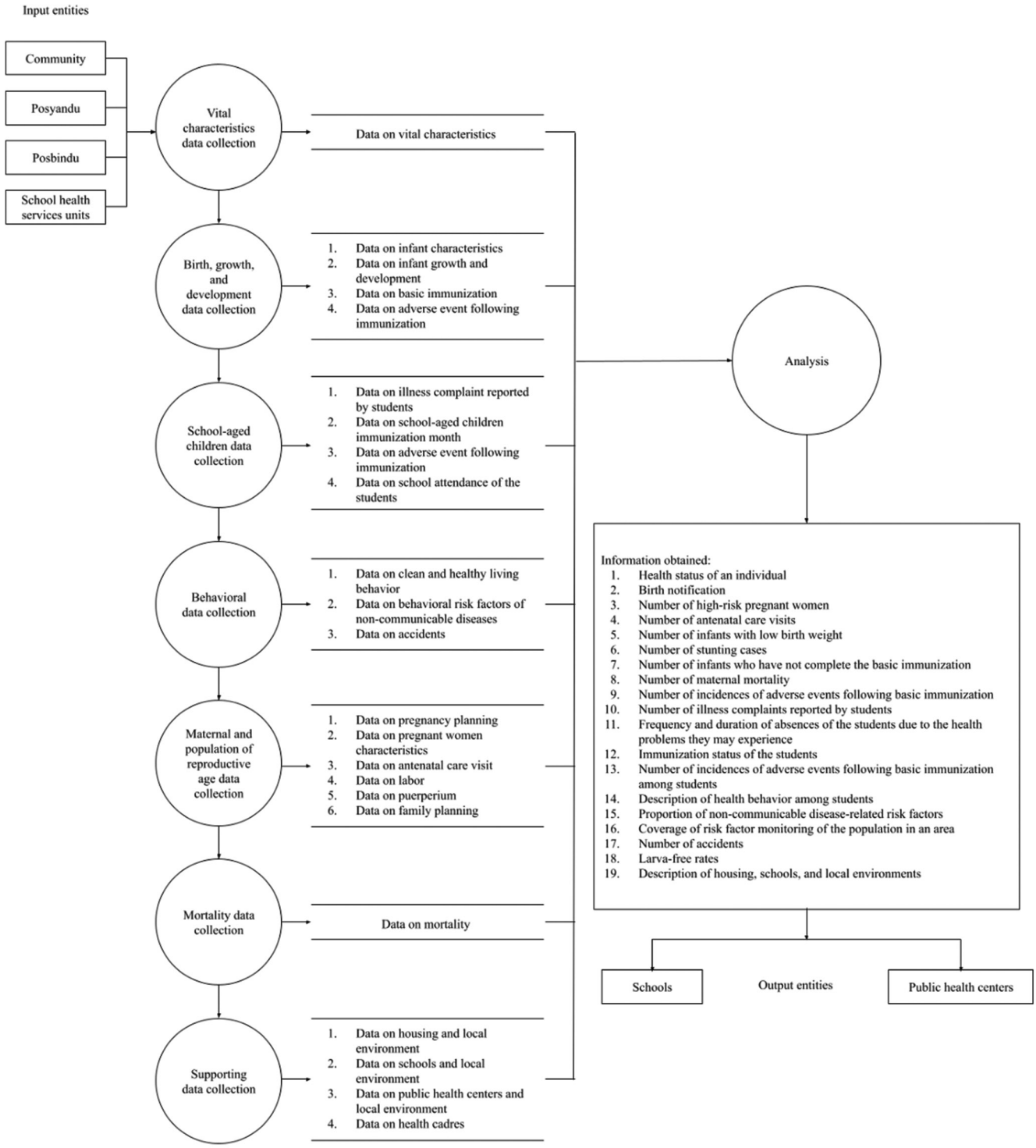

Figure 3: Data flow diagram in integrated health information systems in community-based and school-based public health surveillance

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