Recommendations for respiratory syncytial virus surveillance at national level

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Contributions

ACT, TKF and EVB organised the meeting and had the lead in organizing the manuscript and preparing the first draft. ASB, HC, AM and RR wrote based on the working group discussions sections of the manuscript on respectively RSV surveillance in hospitals, RSV surveillance in the community, Virology aspects of RSV surveillance and RSV surveillance using national registries. All authors critically reviewed the final manuscript and agreed on publication.

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Abstract (250/250 words)

Respiratory syncytial virus (RSV) is a common cause of acute lower respiratory tract infections (ALRI) and hospitalizations among young children and is globally responsible for many deaths in young children, especially in infants below 6 months of age. Furthermore, RSV is a common cause of severe respiratory disease and hospitalization among the elderly. The development of new candidate vaccines and monoclonal antibodies highlights the need for reliable surveillance of RSV. In the European Union (EU), no up-to-date general recommendations on RSV surveillance are currently available. Based on outcomes of a workshop with 29 European experts in the field of RSV virology, epidemiology and public health, we provide recommendations to develop a feasible and sustainable national surveillance strategy for RSV that will enable harmonization and data comparison at the European level. We discuss three surveillance components: active sentinel community surveillance, active sentinel hospital surveillance, and passive laboratory surveillance, using the EU acute respiratory infection (ARI) and WHO extended severe acute respiratory infection (SARI) case definitions. Furthermore, we recommend the use of quantitative reverse transcription polymerase chain reaction (qRT-PCR) based assays as the standard detection method for RSV and virus genetic characterisation, if possible, to monitor genetic evolution. These guidelines provide a basis for a good quality, feasible and affordable surveillance of RSV. Harmonization of surveillance standards at European and global level will contribute to the wider availability of national level RSV surveillance data for regional and global analysis, and estimation of the RSV burden and impact of the future immunization programmes.

Introduction

Human respiratory syncytial virus (formally Human orthopneumovirus, HRSV, here RSV) is an important global respiratory pathogen, affecting mostly the upper airways. Nevertheless, particularly in young children under five years of age, RSV may cause infection of the lower airways, such as bronchiolitis or bronchopneumonia which can lead to respiratory failure. It is the most common cause of hospitalisation among young children admitted for an acute lower respiratory infection (ALRI) worldwide, and is estimated to cause about 120,000 deaths in children under 5 years globally per year [1]. More specifically, almost half of RSV-ALRI associated hospitalizations (45%) and in-hospital deaths (46%) in these children below 5 years old, occur in infants below six months of age. By the age of one year, 60-70% of children have been infected with RSV [2]. Furthermore, RSV infection in early life has been associated with the development of recurrent wheezing and asthma in later infancy and childhood [3]. RSV can cause severe disease in premature infants, infants with co-morbidities (such as congenital heart disease, bronchopulmonary dysplasia and Down's syndrome) [4], in the elderly (≥65 years) [5] and in adults with comorbidities such as chronic obstructive pulmonary disease [6]. In addition to severe respiratory disease, RSV infections also lead to high utilization of outpatient services such as visits to emergency rooms, general practitioners and/or paediatricians, although this impact has not yet been well-defined. As a result of the widespread acute RSV infections and the long-term chronic consequences, most countries are faced with high RSV-associated healthcare expenditures. RSV causes seasonal epidemics worldwide [7], and in Europe RSV has demonstrated seasonality with moderate correlation between timing of the epidemic and higher latitude of the country [8]. In general, RSV activity peaks consistently during

winter months in temperate countries but shows greater variability in seasonal pattern in the tropics [9].

Several candidate RSV vaccines are currently in the pipeline, with a variety of different working mechanisms and target groups, including pregnant women through maternal vaccinations [10]. The first of these current candidate vaccines reported results from a phase 3 trial in 2019 [11]. In addition to the monoclonal antibody palivizumab - recommended as immunoprophylaxis for RSV for high risk infants on a monthly basis before and during the RSV season [12] - a new monoclonal antibody is being developed with an enhanced neutralizing effect and longer half-life [13]. Therefore, it could be well possible that new monoclonal antibodies, if they indeed show higher efficacy and sufficient half-life, and are considered cost-effective, become more broadly available in the population and not only for risk groups. These developments support the prospect that severe RSV infections may be preventable in the coming years. As novel RSV vaccines and monoclonal antibodies are reaching the final stages of development, the need to develop systems for monitoring of population level impact and vaccine effectiveness is becoming more urgent. National and supranational surveillance systems offer an efficient infrastructure to obtain baseline data and for future monitoring impact of RSV immunization programs and effectiveness of RSV vaccines and monoclonals. The World Health Organization (WHO) has started a global effort to develop standards for RSV surveillance, based on the Global Influenza Surveillance and Response System (GISRS) and a pilot study was started in 2017 [14], followed by a three-year extension phase from 2018-2021 [15] in over 20 countries.

In the European Union (EU), no up-to-date general recommendations on RSV surveillance are currently available for Member States who want to establish or improve RSV surveillance. From 1996 to 2008, RSV data were collected and shared through the European Influenza Surveillance Scheme (EISS) [16], which was a disease surveillance network funded (mainly) by the European Commission and based on agreed surveillance recommendations [17]. The main purpose was to estimate the incidence of influenza-like-illness (ILI) during the early part of the influenza season. In September 2008, after moving to the European Centre for Disease Prevention and Control (ECDC), the network was given the name European Influenza Surveillance Network (EISN). Together with the WHO Regional Office for Europe, collection of data on national RSV laboratory test results has continued, but without updating the existing surveillance recommendations. This is because RSV is not yet in the list of notifiable diseases at the EU level (see below). Therefore, RSV surveillance in the EU is currently based on a variety of surveillance platforms [18] that are informative for describing trends and seasonality on the national level, but have poor comparability across countries [8]. These data are also not very useful for estimating healthcare burden or impact of future immunization programs.

In addition to collecting data on laboratory results, nearly all EU/European Economic Area (EEA) countries have a system of primary care (e.g. general practitioners and community-based paediatricians) sentinel surveillance providing data on consultation rates for ILI and/or acute respiratory infection (ARI) and respiratory sampling of patients across all age groups [18]. Testing for RSV for severe acute respiratory infection (SARI) or hospitalised ARI cases is also primarily conducted in hospitals as part of the influenza surveillance programme, and hospital RSV-testing practices are highly variable within and between most European countries [18]. A substantial proportion of young

children hospitalised with lower respiratory tract infections like bronchiolitis and pneumonia are tested for RSV, but the reported differences in RSV detections [8] most likely reflect differences in clinical diagnostic guidelines and protocols rather than real disease prevalence differences.
Many countries in Europe have established national electronic healthcare databases and registries that are currently mainly used to inform policies for immunoprophylaxis [19]. These registries include routinely collected data such as data from laboratory testing, hospital admissions, outpatient and general practitioner (GP) attendances, medical prescriptions and mortality [20]. Healthcare registries usually have complete population coverage and are designed to support direct patient health care delivery [21]. Secondary uses of these data can include surveillance of diseases, research, public health guidance, resource planning and management, and service evaluation and improvement [22]. National laboratory registries for infectious diseases – to which all positive results from any diagnostic laboratory in the country are reported – provide the opportunity for real-time pathogen surveillance.

In order to further enhance and harmonize European collaboration in the field of RSV surveillance, a workshop was organized by ECDC, Statens Serum Institut (SSI) and the National Institute for Public Health and the Environment (RIVM) to develop recommendations for RSV surveillance in Europe. Thirty experts working in the fields of RSV-associated epidemiology, virology, public health and paediatrics, from 17 different European countries and two representatives from ECDC and WHO, participated in this workshop. The recommendations described here provide help to develop a feasible and sustainable surveillance strategy at the national level and enable harmonization and data comparison at the European level. The recommendations can be used by public health institutes to set up new or enhance existing RSV surveillance strategies.

Box 1: Objectives for RSV surveillance

Following an expert consultation in November 2015 [23], ECDC's Advisory Forum considered the potential objectives for RSV surveillance noted below to be appropriate and proportional *(adjusted from [23])*:

1. Describe seasonality and monitor regional, national or European trends for RSV infection
    - to describe RSV circulation and identify the start and end of RSV seasons
    - to inform prevention and treatment strategies
2. Measure positivity rates of RSV across different age groups
3. Measure incidence of RSV infection and support the estimation of healthcare burden of RSV in different age and target groups;
4. Contribute to the overall understanding of the role (e.g. the attributable fraction) of RSV in respiratory disease and define RSV risk groups
5. Monitor genetic and antigenic characteristics and changes of RSV;
    - collect samples to monitor the circulation of the two RSV subtypes, genetic diversity among circulating strains, and the stability of antigenic epitopes targeted by existing and in the pipeline monoclonal antibodies and vaccines
6. Provide a platform and baseline data to estimate the impact of immunization programmes, when available on the market

Linking with the WHO RSV surveillance initiative and EU surveillance infrastructure

Surveillance of RSV in the European region will eventually form a core arm of global surveillance of RSV by WHO. Therefore, we consider it essential to collaborate closely with and contribute to the global RSV surveillance with both clinical and virological data collection. Globally determined RSV surveillance standards and European approaches should be fully aligned in order to avoid conflicting guidance at the national level. Structures such as European RSV reference laboratories (one of the global reference laboratories for the WHO RSV surveillance phase 2 pilot [15] is located in the United Kingdom) would be instrumental for this. The harmonization of surveillance standards at European and global level will ultimately contribute to the delivery of national level RSV surveillance data to regional analyses at ECDC and WHO Regional Office for Europe and further for global analysis at the WHO headquarters, similar to the current routine practice in influenza surveillance [24]. The EU Decision on serious cross-border threats to health (No 1082/2013/EU) [25] mandates the European Commission to establish and update the list of communicable diseases and related special health issues and define the case definitions concerning each communicable disease, as well as update the procedures for the operation of the epidemiological surveillance network. Currently, RSV is not included in the list of diseases to be covered by epidemiological surveillance in the EU. For this reason ECDC has a very limited mandate to develop EU-level surveillance for RSV at the moment. While in some European countries RSV is a notifiable disease, in most countries reporting is voluntary [18]. However, as WHO has proceeded with a global RSV surveillance pilot in more than 20 countries and ECDC has a history of collecting RSV data as part of influenza surveillance and already publishes visual summaries of RSV in its Surveillance Atlas (https://www.ecdc.europa.eu/en/surveillance-atlas-infectious-diseases), there is a need to standardise surveillance systems and data collections across countries and to advocate for the inclusion of RSV on the list of notified diseases.

Recommendations for national RSV surveillance

In the following sections, we provide recommendations for three components of RSV surveillance: 1) active community surveillance, 2) active hospital surveillance (where ICU surveillance can either be a stand-alone surveillance solution or nested within hospital surveillance), and 3) passive surveillance using national healthcare registries. With respect to the implementation of active sentinel RSV surveillance, recommendations for optimal diagnostic and virus characterisation are provided.

The preferred RSV surveillance system will be dependent on the national objectives of the surveillance (box 1 and table 1) and available resources. Active sentinel surveillance systems are used to systematically obtain high-quality data. We recommend either to: 1) use existing RSV surveillance platforms and upgrade these where relevant to accommodate relevant standards, 2) leverage existing surveillance systems for influenza surveillance as cost-effective RSV surveillance platforms [14] or 3) set up active sentinel surveillance systems (community and/or hospital) for fast and efficient extraction of systematically collected high-quality data. Whereas most sentinel surveillance platforms in Europe are based on community cases [18], targeting both community and hospital surveillance within one country would enable insight to be gained on the full spectrum of RSV disease. As the primary aim of a future immunization programme is likely to prevent severe illness in infants, the optimal surveillance platform includes RSV-hospital admission data in infants.

In addition to collecting data from RSV cases, assessing all-cause ARI GP consultations and all-cause SARI admissions may be of value when assessing RSV vaccine effectiveness, since RSV vaccination has been suggested to impact the risk of subsequent (RSV and non-RSV) ALRI and complications [11]. Furthermore, this ARI-based surveillance could facilitate the introduction of a more flexible surveillance system where other respiratory pathogens such as SARS-CoV-2 can be integrated. Surveillance systems based on electronic health registry and/or laboratory data have the advantage of covering a larger part (often comprehensively all) of the population and are less expensive to maintain than sentinel surveillance. Linking to, or using laboratory data is crucial for passive RSV surveillance, given the non-specific clinical symptoms of RSV.

Recommendations for active community and hospital surveillance:

The recommendations in this section apply to active surveillance, both in the community and in hospitals.

Case definitions:

Since the definition of ARI without the necessity of fever is more sensitive than ILI (that requires fever) [26, 27] in capturing RSV infection, the use of the ECDC ARI case definition [28] should be considered as the preferred option for RSV surveillance. This case definition is also recommended for the phase 2 pilot of WHO [29]. This case definition encompasses acute onset of infectious symptoms with at least one respiratory symptom of cough, sore throat, difficult or laboured breathing or coryza. For children <6 months, apnea and sepsis should also be included to cover the wider clinical presentation in this age group.

The SARI case definition for hospital RSV surveillance has been shown to exclude up to 50% of RSV cases in young children and the elderly, because of the requirement for fever [30]. In line with the WHO recommendations for RSV surveillance [14, 29], it is more appropriate to adopt the ECDC ARI case definition with the addition that for hospitalised cases overnight admission is required. This definition is similar to the extended SARI definition of WHO [29] that furthermore includes sepsis and apnea for infants <6 months (figure 1).

Age groups:

RSV infects all age groups, not only infants and frail elderly. Furthermore, the RSV transmission pattern between young and older children or adults, the role of other age groups (including health care workers) in transmitting RSV, and the burden of RSV infection in adults is not well understood and may have important economic consequences. Therefore, specimen collection needs to cover all ages [31]. For feasibility reasons and in keeping with the WHO RSV surveillance phase 2 pilot [15], children younger than two years (who have a high burden of RSV) may be prioritised for specimen collection [1]. Because of the high incidence of RSV and high proportion of severe RSV cases in the first years of life and, in particular, in the first six months [1], adoption of the following age groups is recommended if specific age in months/years cannot be collected: <3 months, 3-5 months, 6-11 months, 12-23 months, 2-4 years, 5-14 years, 15-64 years and 65+ years. This would allow direct comparison of RSV and influenza age data from EISN and the WHO RSV surveillance initiative [14, 29]. If detailed age groups in infants are not possible then sub-groups directly aligned with the above proposed age groups should be adopted (e.g. <2 years and 2-4 years or 0-4 years).

Start and end of each season:

The great majority of RSV cases across Europe is captured between week 40 and week 20 [7], but the onset of RSV circulation is often close to week 40 [8]. To ensure that unexpected early epidemics are identified, to assess regularity of RSV seasons and to be able to document sporadic RSV cases, RSV surveillance should in principle be conducted year-round, at least for the first few years of surveillance. When this is not possible, the focus could be on the season defined through existing multi-year data, typically weeks 40 – 20 [8], but this is only possible in countries with a well characterized RSV season.

Defining the start and end of the RSV season enables the surveillance system to inform to health care providers and health authorities so that measures can be implemented, as needed. Currently, there is no generally accepted method to define the start and the end of RSV season in Europe based on data from a community-based sentinel system. For this reason, each country needs to apply the best calculation method according to availability of the data and local circumstances, until standard methods are agreed upon and widely adopted. Several methods exist (box 2). We recommend the use of either the WHO or the Moving Epidemic Method (MEM) methods, as these can be used prospectively. The MEM method is commonly used for defining the influenza season and additionally assesses intensity levels [32].

Box 2. Methods for defining start and end of RSV season.

Recommended real time methods:

i) Average epidemic curve method: This method, recommended by WHO for influenza surveillance, determines average epidemic curves (appendix 8 of [33]). A specific example of this is the Moving Epidemic Method (MEM) [32, 34]: This method estimates a pre- and post-epidemic threshold, and additional intensity levels of an epidemic, based on data from previous seasons.

Other methods

ii) Annual mean percentage [35]: comparing the weekly proportion of positive tests to the annual mean percentage.

iii) 3% threshold method [36] : threshold of a weekly percentage of 3% tests positive by PCR testing. This could also be used real-time.

iv) 1.2% threshold method [8] : >1.2% of total RSV-positive specimens per country with surveillance system and season RSV detections also exceeding threshold continuously during the season [with one gap week allowed]. This method can be used only retrospectively and can be used when no denominator data on number of tested specimens are available.

Denominators:

Two different denominators are important in RSV community and hospital surveillance. First, the (age-stratified) population denominator to establish the ARI and extended SARI incidence, and second, the number of samples to estimate the percentage of RSV positivity. Methods to calculate incidence rates for SARI and outpatient ILI surveillance described by WHO [33, 37, 38] can also be applied for the incidence of extended SARI and ARI. In some countries, a population denominator will relate to the population served by the sentinel GPs and community paediatricians (e.g. via

patient lists). Also, some countries may have clear catchment areas defined for hospitals. In others, these would need to be estimated using methods described by WHO, e.g. by mapping addresses of patients of a certain sentinel site while also taking into account other health facilities in that area. If this data is not available, additional surveys on healthcare utilization might be necessary [38]. Alternative methods may be used if the catchment population per sentinel site is unknown (e.g. calculate the percentage of sentinel physicians compared to the total number of physicians and apply the percentage to the population pyramid) [39]. These numbers need to be updated every season. For estimation of denominators for RSV positivity, it is important to maintain a weekly record of all tested patients, including those whose sample tested negative for RSV. In circumstances in which the national reference laboratory receives all sentinel samples, a simple (aggregated) denominator of number of all tested specimens can be obtained at the national level to calculate the percentage of positive RSV samples. For this to be reliable, testing should be performed on either all eligible cases, or on a systematic basis, specified a priori. To extrapolate data to the national level for accurate healthcare burden estimates, more detailed population data may be necessary, e.g. on prevalence of risk factors and on health care seeking behaviour [40].

Data reporting:

Countries may consider requesting community and hospital sentinel sites to collect and report individual case-based data (for a limited set of variables (table 2)) by period (week, month) of specimen collection at the national level. Data reporting to the supranational level can also be in case-based format as is already done in the WHO pilot [14]. Reports of case-based data will assist in data validation and linking with laboratory results. Additionally, these data are useful for future vaccine effectiveness calculations. When case-based data are not available for sharing at the national level, data reporting will need to be aggregated by predefined age groups as described above. Weekly data collection, as conducted for influenza surveillance, is likely feasible in many countries. The advantages of weekly data reporting are to identify the start of the RSV season and facilitate health care planning, such as additional bed capacity in hospitals. At a minimum, data should be reported weekly during the respiratory season (weeks 40 – 20) and on a monthly basis thereafter.

In community surveillance systems that are currently reporting and sampling patients who present with ARI in a systematic manner, we recommend leveraging the system to include virological testing of specimens for RSV (including from infants) if these components are not currently in place. Most commercial PCR panels for respiratory testing already include RSV. Recommendations on additional information to collect are presented in table 2. For those systems that currently report and sample patients with ILI symptoms, the following changes are recommended i) expand reporting and sampling to the broader ARI case definition and ii) collect additional data on symptoms if not already done. Patients that are sampled on the broader ARI case definition need to have individual symptoms recorded so that ILI cases can still be extracted from this national case-based dataset. When possible, both ILI and ARI incidence in the community should be reported. This sampling strategy meets the WHO RSV community surveillance guidelines and does not change influenza surveillance according to the present ILI definition. Another advantage of this approach is that influenza cases without typical ILI symptoms, although a minority [26, 41], will also be identified. A practical recommendation when resources do not allow enhanced sampling of ARI patients, is to continue sampling patients presenting with ILI but expand to the broader ARI case definition in the

age groups with the highest RSV burden, i.e. the youngest (< 2 years) and oldest (65 years of age or older) age groups, and to record individual symptoms so that ILI cases can be derived from these data.

Passive surveillance using RSV laboratory surveillance database

Reporting cases through a passive surveillance structure means that there is no active case finding and systematic sampling involved, but that cases are recorded through laboratory and/or clinical coding systems. These cases have generally been tested for RSV for clinical reasons, or have been coded as RSV-cases based on clinical diagnosis.

For passive RSV surveillance, laboratory registry data on RSV testing is the recommended surveillance system. A sustainable, feasible model of an RSV laboratory surveillance database includes the following minimum data elements: an accurate record of the date of sample, patient information (patient ID, date of birth and/or age, sex) and testing information (test type and result, RSV type, and the healthcare setting from where the sample was taken) (Table 3). As a minimum, these reports should include weekly aggregated data on total number of RSV test and RSV-positive laboratory tests, stratified by age group (Table 3). Negative laboratory results provide an exact denominator of number of tested together with number of positive specimens and, therefore, this allows for a more accurate interpretation of trends in RSV-positivity than recording the number of RSV-positive tests alone [42]. Similar to active surveillance, we recommend adoption of the age groups as specified above if individual month/year of age cannot be collected. Although other types of registries could be used to identify RSV-related healthcare episodes, such as hospital admission or GP registries [43], we currently do not recommend these as stand-alone sources for RSV surveillance due to the high variation in quality of diagnostic coding within these type of administrative data and the potential for misclassification bias [20, 44, 45]. The use of ICD10 codes for capturing RSV cases is being assessed [43] and exploring the use of ICD10 codes for RSV surveillance is also one of the goals of the WHO RSV surveillance phase 2 pilot [15].

Virological considerations and recommendations for RSV detection and characterisation

Laboratory confirmation of clinically suspected RSV cases is essential for the accuracy and validity of any surveillance system. Critical factors influencing the sensitivity of virus detection are: sufficient and appropriate specimen sampling as well as timing of sampling as compared to onset of disease, see box 3. Four modalities of tests are being used for RSV detection: molecular detection using nucleic acid amplification (PCR) techniques, direct or indirect immunofluorescence assay (DFA/IFA), rapid antigen detection tests (RADT) and virus culture [46, 47]. Whereas virus culture is still required for studies of phenotypic properties of the virus, it is no longer used as a primary diagnostic tool because of its complexity and long assay duration. Instead of virus culture, quantitative reverse transcription polymerase chain reaction (qRT-PCR) based assays are currently the gold standard and are in widespread use. Despite being less specific and sensitive than qRT-PCR based assays, rapid antigen detection assays are still used because of lower costs and less requirement in terms of time, expertise, and maintenance, compared with qRT- PCR. Serology as a diagnostic tool for use in surveillance is not mentioned here as it is only useful for sero-epidemiological studies and research purposes and not for diagnostics of an acute RSV infection [47]. Genetic characterization of RSV by direct sequencing of sub-genomic regions and or full genomic sequencing will be an important part

of RSV surveillance, to monitor potential antigenic changes in the circulating viruses that might impact the efficacy of future immunization strategies.

Specimen collection, transport and storage

For virological surveillance, specimens could either be collected from all eligible patients, or on a subset of these patients. The number of specimens needed will be dependent on the surveillance objectives and can be calculated using e.g. the ARI incidence, the total population size and the expected RSV positivity [48, 49]. If it is not feasible or necessary to test all eligible patients, patients should be selected on a systematic basis defined a priori (figure 1), e.g. the first predefined number patients per week, or every second patient. For further sequencing, we recommend 10% of the detected viruses at minimum with a minimum of 20 randomly selected per RSV type per country or institute per season; if possible, these should be randomly selected from each age group <3 months, 3-5 months, 6-11 months, 12-23 months, 2-4 years, 5-14 years, 15-64 years and 65+ years (box 5).

Timing of sampling in relation to day of onset of disease greatly impacts the chances of a correct laboratory diagnosis. The duration of RSV shedding in an outpatient setting is on average 9.8±4.8 days for adults [50] and can be even longer (up to 30 days) in children (especially of very young age) [51] and immunocompromised patients [52]. Therefore, patient age and condition, as well as time of sampling from onset of disease should be taken into account when interpreting diagnostic results. The effect of shedding patterns on confirmation of the presence of RSV in a clinical specimen depends on the technique used. The number of positive patients drops more rapidly with time since onset of disease using antigen detection compared to qRT-PCR, indicating that the sensitivity of antigen detection is only high during the first few days after onset of disease [53]. For highest sensitivity in any test, we recommend specimen collection preferably in the first 4 days following onset of disease for routine diagnostics. However, collection can reliably be done up to 10 days following onset of disease or even longer (taking into account assay-type sensitivity as well as patient age and condition-specific limitations that influence the shedding period) [50-53]. In the hospital setting, specimens should be collected as soon as possible after admission.

The anatomical site from which specimens are collected is also important for the sensitivity of diagnostic laboratory tests. Nasopharyngeal swabs are more sensitive than oropharyngeal swabs due to higher viral load in the nasopharynx compared to the oropharynx [54]. Also, nasopharyngeal specimens compared to mid-turbinate specimens seem to have greater sensitivity for RSV due to the higher amount of cells collected [55, 56]. Therefore, we recommend only using nasopharyngeal swab for surveillance purposes. Although the WHO RSV surveillance initiative recommends URT and the more invasive LRT for sampling (see supplementary table 1 [57, 58]), using the less invasive nasopharyngeal swab only for surveillance purposes [54, 59] may be beneficial and lead to higher acceptance among participants. For the youngest children mid-turbinate sampling rather than nasopharyngeal sampling might be considered as less challenging. For routine diagnostics, we recommend following the guidelines for age-group specific optimal sampling of anatomical sites and type of clinical specimens provided by the WHO RSV surveillance initiative [57].

Flocked swabs are slightly preferable to rayon swabs because they are more efficient in collecting infected epithelial cells [55, 60]. This is of benefit for molecular techniques [60] and antigen detection, but especially for DFA/IFA [55]. Swabs with a cotton tip, calcium alginate-aluminium

swabs and swabs with wooden shaft should not be used because of inhibition of PCR and/or virus isolation [61, 62]. Therefore, we recommend flocked swabs with a plastic shaft. The transport medium should enhance preservation of infectivity of the virus and integrity of RNA and prevent overgrowth of bacteria during transport [63]. Transport and storage of specimens should also take into account the subsequent analysis type as conditions for molecular and antigen detection are less critical than for virus isolation [63-65]. Regarding viral transport medium, we recommend following WHO guidelines, which include guidance for commercial as well as in-house laboratory developed tests [66]. We recommend sending specimens to the laboratory as soon as possible after sampling and preferably the same day or the next day, at the latest. Specimens should be stored at 4°C until transport to prevent viral RNA degrading. For virus isolation, the specimen should ideally be transferred immediately to the laboratory and inoculated on cells, where applicable. If the specimen needs to be transported, it should be kept at 4°C at all times and the time between specimen collection and transport should ensure same day arrival at the laboratory and testing and/or inoculation on cells [64, 67]. Transport of specimens for routine testing can be done at ambient temperature in regions with a temperate climate. When the ambient temperature exceeds 25°C, transport should ideally be done at 4°C. Upon arrival at the laboratory, the specimen should be aliquoted; one aliquot kept at 4°C for testing within 1 to 3 days and the other aliquots stored at -70°C or lower for future testing. As a guideline at least the RSV-positive specimens should be stored in the freezer until genetic characterisation for a season is completed. A subset of sequenced clinical specimens should be stored for a longer time as reference material; duration depending on available freezer capacity. If specimens need to be stored for future virus isolation, an infectivity-preservative should be added first and freezing avoided [65]. Cultured viruses should be stored in a biobank for antigenic characterization and as reference material; duration depending on available freezer capacity.

Box 3: summary of recommendations on specimen collection, transport and storage

- Specimen collection: all eligible patients or systematic selection
- Timing of specimen collection:
    - Routine diagnostics: specimen should be collected preferably in the first 4 days following onset of disease
    - Hospital setting: specimens should be collected as soon as possible after admission
- Site of sampling:
    - Nasopharyngeal specimens give the best sensitivity
    - Routine diagnostics: follow guidelines of WHO RSV surveillance initiative including URT and LRT sampling
    - Surveillance purpose: less invasive URT sampling only should be considered to encourage patient participation.
- Sampling and transport:
    - Use flocked swab with a plastic shaft
    - Send specimens to the laboratory as soon as possible after sampling, preferably the same day
    - Store specimens at ~4°C until transport
    - Transport at ambient temperature if temperature <25°C. If ambient temperature is higher, transport at ~4°C

Detection methods

Molecular detection: The landscape of molecular detection assays in use for RSV diagnostics is illustrated by the results of three RSV external quality assessment (EQA) programmes of Quality Control for Molecular Diagnostics (QCMD) carried out in 2018 (results used with permission from QCMD). For the three programmes, 118, 89 and 86 datasets were reported by 101, 72 and 72 laboratories, respectively, and this exercise described the current practice of specialist and general clinical laboratories worldwide. Of these laboratories, 63% to 72% used commercial molecular detection assays and 28% to 37% used in-house developed molecular assays. Commercial assays included RSV specific assays and multiplex respiratory panel assays including RSV. Some of these assays are considered molecular point-of-care tests (mPOCT), which are increasingly being used, especially for emergency room testing. Only 21% to 29% of laboratories reported typing information indicating the majority of tests did not differentiate between RSV-A and RSV-B. The majority of assays used (47-72%) targeted the nucleoprotein (N) gene (Figure 2 for the RSV genomic overall structure for genes coding the indicated proteins). Other genes targeted were the matrix (M) protein gene (10-22%) and the fusion glycoprotein (F) gene (6-12%) or genes coding for the large polymerase subunit (L), non-structural protein-1 (NS-1) or -2 (NS-2), the M2-2 transcription factor or phosphoprotein (P) (each <3%). Despite this diversity in the targeted genes, there were no differences in the capability to detect and differentiate RSV-A and RSV-B and no obvious differences in sensitivity. However, at least annual review of primers and probes against available sequence data is needed as ongoing evolution may lead to mutations in primer and probe target sites and subsequently to reduced sensitivity and under-recognition [68, 69]. As for other viral RNA detection assays, virus controls should be updated frequently to include new emerging variants that may impact assay performance.

Antigen detection: RSV antigen detection by RADT through capture of antigen and by DFA/IFA through detection of antigen in infected cells by monoclonal antibodies are both less sensitive than qRT-PCR [70]. They suffer from higher false positive results due to cross-reactivity with similar proteins of related viruses, and higher false negative results mostly due to antigenic variation among viruses [71]. The protein most often targeted is the F-protein, but the N-protein and G-protein are also used. Mutations in the genes coding for these proteins may result in changes in antigenic epitopes used by the detecting antibodies. A recent study concluded that for optimal development of monoclonal antibodies, only selected regions of F and N should be used and combined with selected regions of G. This is because F and N of RSV and of human metapneumovirus (hMPV) are highly related and can cause false positivity [71]. Indeed, this type of targeted development of monoclonal antibodies, although against other proteins, was shown to result in higher sensitivity and specificity in the ELISA format [72]. Nevertheless, the key advantage of RADT (its faster turnaround-time) has been challenged by mPOCTs, which are increasingly used in clinical laboratories and which provide results in a turnaround-time comparable to RADT, but with the performance of qRT-PCR [73].

Virus isolation: RSV is a virus that rapidly loses infectivity if not appropriately treated after a specimen has been collected. Increased temperature, freeze-thaw cycles, and changes in pH have a detrimental effect on viral infectivity [64]. Immediate inoculation of cells, appropriate specimen collection, and addition of phosphate sucrose to preserve infectivity in storage medium, improves the success of virus isolation [65, 67]. The most commonly used cell-line for RSV isolation from

clinical specimens is HEp-2, although A549 cells are also widely used [46]. Although virus isolation as a diagnostic test has been replaced largely by molecular and antigenic tests [46], cultivation is still needed to obtain viruses for phenotypic analysis (e.g. for analyzing susceptibility to vaccine induced neutralizing antibodies, antiviral susceptibility, and antigenic likeness with vaccine strains) and as controls for other assay types.

Based on these data, we have three recommendations for RSV detection, listed in box 4.

Box 4: Summary of detection recommendations

Given the strengths and weaknesses of the methods for RSV detection in clinical specimens described above, we recommend:

1. qRT-PCR (either in-house, commercial or in mPOCT format) as the standard detection method;
    a. Capable to detect both RSV types A and B and optimally also distinguishing between types A and B;
    b. Ideally, targeting at least two of the highly conserved genes as N, P, M or L;
2. Pre-seasonal review of primers and probes against sequences of recent circulating strains;
3. Annual evaluation of assay performance by EQA

Genotyping

Sequencing of the RSV genome or sub-genomic regions serves different purposes: description of genetic evolution and global spread of RSV [74, 75], examination of the association of genotypes with severity of disease [76, 77] and monitoring the evolution of proteins that are targets for antigen detection and vaccines (active and passive) and antivirals under development [78, 79]. In particular, any possible changes in the virus that may be accelerated by the implementation of an immunization programme should be carefully identified and followed up.

Recent studies with full RSV genomes show the complexity of RSV evolution that has not been captured previously with sequencing of sub-genomic regions [74, 80]. Comparison of different studies is complicated by the lack of standardization of the nomenclature for RSV strains and genomic clades and of criteria for assigning genomic clades. Combined analysis of sequences (G-protein gene as well as full genome) from different studies assigned viruses with different country-specific clade nomenclature actually to the same clade [74, 81]. Whole genomes show that RSV circulates on a global scale with the same predominant clades of viruses being found in countries around the world [74]. This global analysis showed also that complete G-protein gene sequences, but no other genes nor the widely used partial G-protein gene sequences, generated similar phylogenetic topology compared to whole genomes [74]. Therefore, consensus over sequencing sub-genomic regions and criteria and nomenclature for genomic clades is needed to maximize the ability to share sequence data for merged analysis. Furthermore, sequence sharing should be facilitated by the development of a global curated database dedicated to RSV, similar to the GISAID database for influenza. Whole genome sequencing should be performed, preferably for at least a representative subset and if that is not feasible, full G-protein gene for phylogenetic analysis. In addition, we consider sequencing of the F-protein gene to also be highly relevant as the F-protein has been shown to demonstrate significant variability [82] and is targeted by several promising vaccines under development and by the therapeutic monoclonal antibodies either existing or under

development , as well as by antivirals [10]. Recommendations for genotypic characterization are summarized in box 5.

Box 5: Summary of genotyping

As guidance for representative sequencing we recommend:

1. Sequencing of the whole G-protein gene as a minimum or if possible full genomes for molecular epidemiology and analysis of potential impact of amino acid changes on epidemiology and severity of disease;
2. Sequencing of the F-protein gene, at a minimum covering antigenic sites Ø and II for analysing potential impact of amino acid changes on antigenicity;
3. Sequencing of 10% of detected viruses at minimum with a minimum of 20 randomly selected per RSV type per country or institute per season; if possible samples should be randomly selected from each age group <3 months, 3-5 months, 6-11 months, 12-23 months, 2-4 years, 5-14 years, 15-64 years and 65+ years.

Phenotypic characterization

The study of phenotypic properties is necessary to understand the impact of genetic diversification on e.g. virus replication [75] and proposed effectiveness of immunization [79] and antivirals [78]. For protective antibody response analysis following vaccination in addition to availability of recently circulating strains pre- and post-vaccination serum specimens are needed [83]. Antigenic characterization can be performed using neutralization assays in cell culture systems.

External Quality Assessment

EQA is an important mechanism by which the quality of performance of laboratories to detect RSV can be assessed, even when these laboratories use a wide variety of molecular techniques [45]. However, strains used in EQA panels are often outdated or not characterized [84]. Recent changes in RSV that may affect the sensitivity or even capability to detect new strains [69] may not be covered by EQA schemes providing false confidence in performance of used tests. One of the objectives of the second phase of the WHO RSV pilot is performing an RSV-detection and typing EQA using molecular diagnostics with a panel composition that takes these considerations into account [85]. EQA schemes for RSV isolation, DFA/IFA or RADT are not widely available. However, several national schemes offer such specialised EQAs (e.g. [86]). Increased use of sequence analysis including next generation sequencing (NGS) techniques necessitates the establishment of an EQA scheme for NGS-based and full genome analysis [87]. With immunization strategies on the horizon, EQA for characterization of RSV antigenic drift may become relevant in the near future.

Ethical and governance considerations

When setting up or altering RSV surveillance systems, public health institutes and national governments need to be aware of the legal and ethical considerations of surveillance systems. WHO recently published guidelines on the obligations that countries, (public health) institutes and global communities have to ensure that surveillance will be well conducted in terms of privacy, autonomy, equity and the common good [88]. At the European level, the new EU General Data Protection Regulation (GDPR) regulates the processing of data by an individual, a company or an organisation of personal data relating to individuals [89]. Personal data that are identifiable or pseudonymised and

therefore theoretically traceable are all within the scope of the GDPR. Only data that are irreversibly anonymised are not considered as personal data [89]. This is of importance both at the national level and when sharing data at the European or global level. One of the crucial factors is whether RSV surveillance falls under the umbrella of lawful purposes, which amongst others depends on the decision of European commission to add RSV to the list of reportable diseases at EU level. At the national level, the practical interpretation of the GDPR will be slightly different across countries, depending on national legislation.

Discussion

In this article we provide suggested guidelines to prioritize and shape new and enhanced RSV surveillance systems, building on the recommendations developed in 2006 by the European Influenza Surveillance System [17] and considering the findings of the WHO RSV surveillance pilot [14, 29, 40]. Minimum dataset requirements are outlined to allow comparison of a core dataset at European level. We also propose recommendations for optimal requirements, where feasible, for data collection and reporting on a national level and /or EU level. Furthermore, we also propose recommendations for optimal diagnostics to support sensitive surveillance of RSV. These include the best respiratory tract sampling site and procedure, optimum time period after onset of diseases for specimen collection, optimal specimen transport conditions, most sensitive techniques for virus detection and external quality assessment procedures. Since resources for surveillance are limited, assessing trends and seasonality (objective 1) are the minimum requirements for sustainable and feasible surveillance on the European scale. Depending on available resources and the health care system within each country, either active sentinel surveillance or passive laboratory register surveillance could be applied to achieve this. Secondly, setting up a platform to assess impact of immunization (objective 6) is highly relevant in countries that may be introducing the immunization strategies into national programmes, given the current developments regarding candidate RSV vaccines and monoclonal antibodies [90]. However, a surveillance system where impact of the programme and immunization/vaccine effectiveness can be assessed will require more extensive development, both in terms of patient numbers and in information that is required per patient. A surveillance system that is set up to assess the impact of immunization programmes would be more beneficial if it additionally covers other RSV surveillance objectives, as described in this manuscript. It will be important to harmonise data collection for impact assessment in different countries, so data could theoretically be pooled as is done for influenza VE by the I-MOVE project [91, 92]. Adding sequence data will be important to interpret VE outcomes correctly or even stratify VE according to emerging clades with altered antigenic sites.

We suggest using the extended SARI case definition, instead of the SARI case definition as used in influenza surveillance. Although it will be less informative to compare extended SARI RSV and SARI influenza incidences in hospital, this extended SARI definition will be more sensitive for capturing RSV cases.

Integration of RSV surveillance into other respiratory surveillance systems, as recommended by ECDC advisory forum (personal communication E. Broberg) and WHO [14] should make RSV surveillance more feasible. The use of the ECDC ARI and extended SARI case definitions, as suggested here, should allow the future extension of the surveillance with other pathogens if necessary, by assessing those pathogens in the same specimens.

Which of the surveillance components discussed here can be best applied in a country will also depend on the national health care system and the health care seeking behaviour of different population strata. In some countries, for example, parents will be more likely to visit emergency departments of hospitals with symptomatic children than primary care. In others, working age adults will seek primary care for insurance purposes. Implementation should, therefore, be seen in the context of other existing or future surveillance activities, such as laboratory or hospital-based surveillance. Hospital-based surveillance for RSV is currently not implemented in many countries in Europe [18], and could first be piloted at a limited number of sentinel sites in a few countries to identify challenges and barriers to implementation before being scaled up at national level throughout Europe.

In general, the preferred RSV surveillance system will be active sentinel surveillance, with both primary care and hospital patients being systematically sampled and tested for RSV. One important limitation of this surveillance system could be that the use of ARI case definition may increase the burden and will be a major change for the physicians, who often have participated in the existing surveillance networks of ILI for a long time. These two components may compromise influenza surveillance and this should be monitored carefully. However, according to the first results of the WHO pilot, combining RSV and influenza surveillance into one system actually appeared beneficial for both systems [14]. Furthermore, the costs and efforts to add RSV as a component this surveillance were reported to be marginal incremental costs [14]. Coordinated planning should also consider the need for COVID-19 surveillance, which has been included in sentinel influenza surveillance schemes in many countries during 2020. To assess total burden of RSV, monitoring and sampling of community patients with otitis media (OM), that poses a substantial socio-economic as well as healthcare burden, could be additionally considered. Since this is rather a sequela of RSV associated ARI this is better captured outwith an ARI or SARI based surveillance through well designed prospective clinical studies.

Surveillance in ICUs could be considered, as part of total hospital surveillance or stand alone, using the same extended SARI case definition. Specific surveillance on neonatal or paediatric ICUs would however be needed to cover the lowest age group.

The benefits of using passive surveillance of RSV, via laboratory database surveillance, is that it is nationally representative and is a relatively inexpensive strategy compared to active surveillance, once set up [28, 93]. Furthermore, inclusion of a personal identifier within the laboratory surveillance dataset where feasible, allows linkage to other national databases such as clinical data or vaccination or immunization registries. This will likely not facilitate real-time surveillance, but would allow secondary research where appropriate [93]. Measures to ensure data privacy would be necessary to allow linkage of the data. Introducing RSV to the list of notifiable diseases (e.g. by laboratories) could be an alternative method of providing the number of positive RSV cases per age group to cover the minimum reported data.

However, laboratory database-based surveillance also has limitations. Firstly, minimal or no clinical data are available and variation or changes in policy, health service capacity, healthcare seeking behaviour and testing practices cannot be controlled for unless negative tests and clinical data are also recorded. Secondly, while many countries in the Northern, Central and Western European

regions have established national electronic healthcare databases, many countries in the Eastern Europe do not currently have electronic healthcare databases [19]. A lack of resources to set up such a national registry is likely to limit the capacity to set up an RSV laboratory surveillance database [94]. Similarly, there is a difficulty in capturing clinical information within the surveillance database without requiring additional resources from the reporting laboratories. Furthermore, the increasing use of mPOCT in hospitals, often without involvement of the laboratory [95] may greatly impact the number of reported cases to national public health institutes, especially if the levels of recording in clinical records, reporting to laboratories and the registration of negative test results are unknown. Finally, if patient identifiers (or patient identifiable information) are not included in the database, it would not be possible to carry out de-duplication and individual-level analysis, or linkage to other existing, structured datasets containing clinical information. This linking of clinical data with laboratory information is important to support research on the burden of RSV and cost effectiveness analysis of future RSV immunization strategies.

Critical for ascertainment of a laboratory confirmed case of RSV infection is optimal sampling and transport of specimens as outlined in box 3. For surveillance purposes we recommend using nasopharyngeal swab only, whereas the WHO initiative recommends collection of upper respiratory and lower respiratory specimens as well (see supplementary table 1 [57, 58]). In our opinion a slightly lower sensitivity when using URT nasopharyngeal swabs is only acceptable if this significantly reduces the rate of refusals of, in particular, parents to have their sick children sampled. We recommend the use of real-time RT-PCR or its mPOCT equivalent for most sensitive detection of RSV. Harmonising this approach by using one type and brand of test by all surveillance sites is not recommended as it is not practical, and may lead to delays in recognising when there are issues with assay sensitivity/specificity or other test failures for whatever reason [69]. Therefore, the use of a diverse palette of clinically well validated and well performing tests (despite being variable in design) is preferable. However, quality should be assessed annually by EQA and primers and probes checked for fit with recent circulating strains. For commercially available tests, the manufacturer is responsible for the latter if the manufacturer does not release primer and probe information.

Conclusions:

To facilitate countries establishing or upgrading existing RSV surveillance, we propose three different types of surveillance: active sentinel community surveillance, active sentinel hospital surveillance and passive laboratory surveillance, considering ethical and policy-related issues. Based on current diagnostics, we propose the use of the quantitative reverse transcription polymerase chain reaction (qRT-PCR) based assays as the standard detection method for RSV and virus genetic characterisation, if possible, to monitor genetic evolution. These guidelines should provide the basis for a feasible, affordable and robust RSV-surveillance-system for RSV in Europe and beyond: it offers a unique platform for comparison of RSV activity, virological features and disease burden locally, nationally and across county borders. This represents a possible solution to the unmet need for estimating RSV healthcare burden as well as providing the basis for an approach to assessing impact of future immunization programmes.

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Figure 1. Testing and diagnostic algorithm for RSV surveillance - Active community surveillance and active hospital surveillance

Footnotes:

a. Sepsis defined as: fever more than 37.5°C or hypothermia, shock or seriously ill without apparent cause.

b. Using nasopharyngeal swab, within 10 days after onset of disease but ideally within 4 days after onset, by qRT-PCR or mPOCT, ideally distinguishing by type A and B

c. Note that (background) denominator data are needed

d. Note that additional variables (e.g. vaccination coverage) are needed.

Figure 2: RSV genomic overall structure of genes coding for proteins

Table 1. Potential objectives of RSV surveillance and corresponding surveillance data indicators from sentinel and registry based surveillance

Objective	Sentinel surveillance (community and hospital)	Passive surveillance using RSV laboratory surveillance database
1. Describe seasonality and trends for RSV	- ARI/extended SARI incidence - ARI/extended SARI RSV incidence	- RSV laboratory confirmed cases
2. **Measure positivity rates of RSV across different age groups**	- % of RSV among ARI/extended SARI cases	- % of RSV among tested patients
3. Support the estimation of healthcare burden of RSV	- Proportion of hospitalizations associated with RSV - ARI/extended SARI incidence - ARI/extended SARI RSV incidence	- RSV laboratory confirmed cases - Duration of hospitalization, Etc.
4. Contribute to the overall understanding of the role of RSV in respiratory disease	- % of RSV among ARI/extended SARI cases - Ratios of RSV positivity compared with other respiratory pathogens	- Ratios of RSV detections/cases compared to detections/cases of other pathogens.
5. RSV types and genetic diversity	- Genotypic characterization - Phenotypic characterization	- Sequence data stored in an RSV dedicated or general (GenBank) sequence database - Existing laboratory databases containing detailed genetic information
6. Platform and baseline to access impact of immunization programmes	- VE of RSV ARI/extended SARI - VE of RSV bronchiolitis (hospital only) - RSV incidence before and after implementation (focus on primary target group for vaccination)	- If immunization status is available: VE among different risk groups - RSV incidence before and after implementation (focus on primary target group for vaccination)

Footnote: ARI: acute respiratory infection; extended SARI= extended severe acute respiratory infection; RSV: respiratory syncytial virus; VE: vaccine effectiveness (this term includes the effectiveness of monoclonal antibodies)

Table 2 Recommended set of core and other optional variables in case based reporting of community and hospital surveillance.

	Community surveillance	**Hospital surveillance**
CORE SET variables		
Patient variables	Date of consultation	Date of admission
	Age in years[1]	Age in years[1]
	Age in months (children <24 months of age)[2]	Age in months (children <24 months of age)[2]
	Sex	Sex
Clinical variables	Date of onset	Date of onset
	Measured temperature >38C, Cough, sore throat, coryza, difficult or laboured breathing, (for infants <6 months of age:) apnea, sepsis [3]	Measured temperature >38C, Cough, sore throat, coryza, difficult or laboured breathing, respiratory rate frequency above WHO threshold for pneumonia[4], (for infants <6 months of age:) apnea, sepsis [3]
Virological variables	Date of sampling	Date of sampling
	Type of specimen	Type of specimen
	RSV detection result pos/neg	RSV detection result pos/neg
	RSV type For subset: genotyping and analysis of antigenic sites	RSV type For subset: genotyping and analysis of antigenic sites
Other optional variables		
Clinical variables[5]		Length of stay (days)
		Supplemental oxygen use (yes/no)
		ICU admission yes/no
		Ventilatory support (yes/no OR subdivided in invasive and non-invasive)
		Died during hospitalization (yes/no)
	RSV Vaccination status of patient[5]	RSV Vaccination status of patient[5]
	RSV Vaccination status of mother (for children < 1 year)[6]	RSV Vaccination status of mother (for children < 1 year)[6]
	Monoclonal antibodies use	Monoclonal antibodies use
	If yes, date of most recent monoclonal Ab use	If yes, date of most recent monoclonal Ab use

Risk groups	Preterm birth (<37 weeks of gestation)	Preterm birth (<37 weeks of gestation)
	Underlying conditions	Underlying conditions

Footnotes:

1. For the oldest age groups, a category such as 90+ may be required depending on the size of demographic strata for reported data to be anonymised
2. If strata are too small, age groups (<3 months, 3-5 months, 6-11 months, 12-23 months) could be used
3. All variables should be recorded as Yes/No/Unknown
4. WHO respiratory rate threshold for pneumonia [96]:
    a. < 2months of age: ≥ 60 breaths/min
    b. 2 – 11 months of age: ≥ 50 breaths/min
    c. 12- 59 months of age: ≥ 40 breaths/min
    d. ≥ 60 months of age: ≥ 20 breaths/min
5. Some optional outcomes would require follow up of the patients during hospitalization. This will not be feasible in all surveillance settings.
6. Vaccination status is depending on availability of vaccine and the type of vaccination (maternal, paediatric, etc).

Table 3. Optimal data elements to be collected on all RSV laboratory tests in an RSV laboratory surveillance dataset and core data on RSV-positive laboratory tests to be reported as a minimum.

Core data elements to be collected	**Minimum reported data**
Patient ID and/or personal identifier	
Date of birth AND/OR age at sampling	Minimum: age group[1,2] Preferably: • Age in months (children <24 months of age • Age in years
Date of sample	ISO calendar week and year of sample
Sex	Female/male/other/unknown
Reporting laboratory/site	Data source[3] or laboratory ID
Test type	PCR/antigen/rapid test/etc
Test result	Positive/Negative
RSV type	A/B/Untyped
Healthcare setting	Hospital/ICU/GP/unknown

1. For the oldest age groups, a category such as 90+ may be required depending on the size of demographic strata for reported data to be anonymised
2. If strata are too small, age groups (<3 months, 3-5 months, 6-11 months, 12-23 months) could be used
3. Data source is a more comprehensive description of surveillance system where multiple variables (e.g. geographical coverage, population, active/passive, sentinel/comprehensive) within data source need to be defined. This is reported only when specific surveillance type is started or if there are changes to the system.

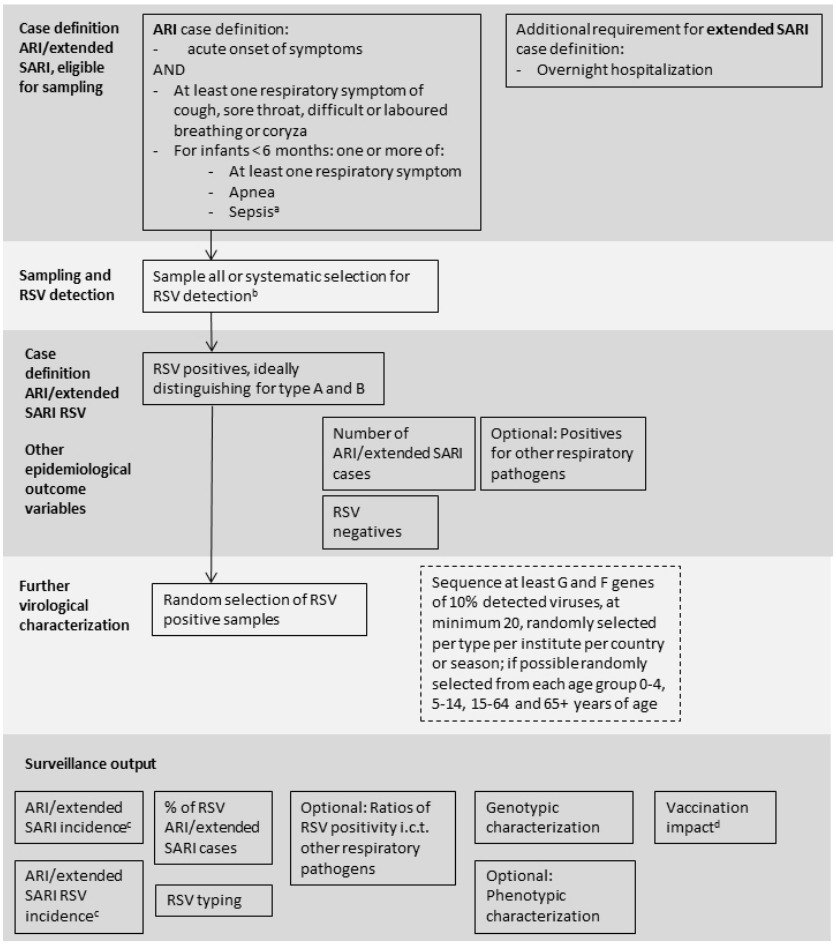

Figure 1. Testing and diagnostic algorithm for RSV surveillance - Active community surveillance and active hospital surveillance

a. Sepsis defined as: fever more than 37.5°C or hypothermia, shock or seriously ill without apparent cause.
b. Using nasopharyngeal swab, within 10 days after onset of disease but ideally within 4 days after onset, by qRT-PCR or mPOCT, ideally distinguishing by type A and B
c. Note that (background) denominator data are needed
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190x275mm (96 x 96 DPI)

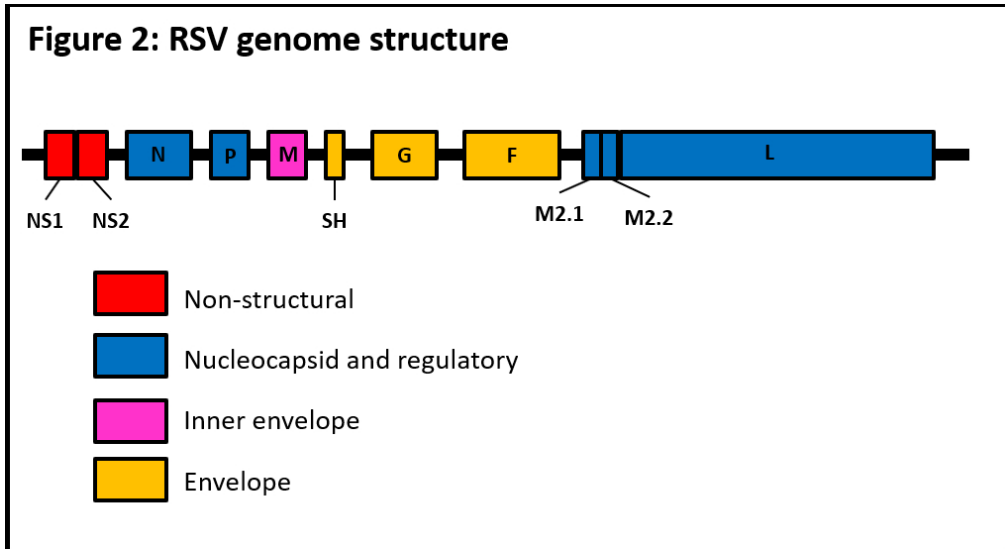

Figure 2: RSV genomic overall structure of genes coding for proteins

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Supplementary table 1. Specimen collection guidelines from suspect RSV cases from WHO RSV pilot. Source: https://www.who.int/influenza/rsv/rsv_collection_transport_storage_samples/en/ [57]

Age	Optimal sample	Anatomical site
Infants and young children (≤ 5 years)	Nasopharyngeal swab, aspirate or nasal swab	URT - mid-turbinate nostril
Older children, adolescents and adults (>5 years and ≤ 65 years)	Nasal and/or throat swabs collected into the same transport tube	URT
	LRT specimens including: tracheal aspirates/ broncho-alveolar lavage	LRT
Older adults and elderly (>65 years)	Nasopharyngeal aspirate/swab	URT
	Sputum samples	LRT
	LRT specimens including: tracheal aspirates/ broncho-alveolar lavage	LRT

URT =Upper Respiratory Tract; LRT=Lower Respiratory Tract.