Self-identification of the clinical fertile window and the ovulation period

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Objective: To assess the sensitivity and specificity of the self-identified fertile window.

Design: Observational study.

Setting: Not applicable.

Patients: A total of 107 women.

Intervention(s): Women recorded cervical mucus observation and basal body temperature daily while undergoing daily ovarian ultrasound.

Main Outcome Measure(s): The biological fertile window, defined as the 6 days up to and including the day of ovulation; and the 2-day ovulation window, defined as the day before and the day of ovulation.

Result(s): The self-identification of the biological fertile window by the observation of any type of cervical mucus provides 100% sensitivity but poor specificity, yielding a clinical fertile window of 11 days. However, the identification of the biological fertile window by peak mucus (defined as clear, slippery, or stretchy mucus related to estrogen) yielded 96% sensitivity and improved specificity. The appearance of the peak mucus preceded the biological fertile window in less than 10% of the cycles. Likewise, this type of mucus identified the ovulation window with 88% sensitivity.

Conclusion(s): These results suggest that, when perceived accurately, more accurate clinical self-detection of the fertile window can be obtained by identification of peak mucus. This may improve efforts to focus intercourse in the fertile phase for couples with fertility concerns. (Fertil Steril © 2015;103:1319–25. © 2015 by American Society for Reproductive Medicine.)

Key Words: Fertile window, ovulation, menstrual cycle, fertility awareness methods, cervical mucus

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ecently, there has been renewed interest in the concept of the fertile window of the menstrual cycle (1, 2). This window of fertility is the period of the cycle during which sexual intercourse may result in conception. Traditionally the menstrual cycle has been divided into two phases: the preovulatory (or follicular) phase, from the first day of menses up to the end of the ovulation day; and the postovulatory (or luteal) phase, from the day following ovulation to the onset of the next menses. Recognizing the importance of the fertile window, it may be more appropriate to divide the follicular phase of the menstrual cycle into two sub-phases: the latency phase (3) and the fertile window. The postovulatory (luteal) phase would then become the third phase of the cycle. In addition, Wilcox et al. (4) estimated the probability of conception beginning 5 days before ovulation and ending on the day of ovulation itself. In this article, this 6-day window is called the biological fertile window (BFW). However, a more precise terminology might be “the 6-day fertile window” indexed to
MATERIALS AND METHODS

Patients

Patients were recruited from 1996 to 1997 from eight natural family planning clinics located in France, Italy, Germany, Belgium, and Spain. The inclusion criteria consisted of women aged 19–45 years inclusive, with previous menstrual cycle lengths of 24–34 days inclusive.

Exclusion criteria included women with a consistent history of anovulatory cycles, infertility, or active hormonal treatment of infertility in the past 3 months, use of hormonal contraception or hormonal replacement in the past 3 months, abnormal cycles (polycystic ovarian syndrome or luteal phase defect), hysterectomy, tubal ligation(s), and pelvic inflammatory disease. In addition, runners and breastfeeding or postpartum mothers (<3 months) were excluded.

A total of 107 women were finally recruited, contributing an average of three cycles. The study examined 326 cycles.

The study was approved by the local ethics committee (Comité Consultatif de Protection des Personnes dans la Recherche Biomédicale de Lyon). All the participants gave their written informed consent, and the study procedures were carried out in accordance with the Ethical Standards for Human Experimentation established by the Declaration of Helsinki.

Assessments

Cervical mucus. Cervical mucus at the vulva was assessed by participants two to three times daily, to record the sensation (dry, moist, wet, and slippery), appearance (white/yellow, clear), and the consistency (tacky, creamy, stretchy). On the basis of the Colombo and Masarotto definitions (18), a four-point score was defined: [1] dry sensation, rough and itchy or nothing felt/nothing seen; [2] no longer dry sensation/nothing seen; [3] damp sensation, with or without appearance of thick, creamy, whitish, yellowish, or sticky mucus; [4] wet, slippery sensation with or without the appearance of clear, stretchy mucus (similar to a raw egg white). If a discharge exhibited mixed characteristics, or if a woman observed multiple types of mucus through the course of the day, the highest matching category was chosen to assign the score. Mucus corresponding to a Colombo score of 4 is what we have identified as peak mucus in this article. The last day of continuous peak mucus is known as the “peak sign” (8). The fourth day after the peak sign was considered the beginning of the postovulatory (luteal) phase.

Basal body temperature. Basal body temperature was to be taken daily upon waking, before any activity, and recorded on an individual chart together with the date, the cycle day, and any condition affecting temperature (e.g., stress, illness, insomnia). We adopted the British Life Assurance Trust (BLAT)-World Health Organization (WHO) rule to read the BBT (19): a cover line was drawn 0.05°C above the temperature points separating lower temperatures in the first part of the cycle from higher temperatures in the second part of the cycle. To draw the cover line, all temperatures (a minimum of six) from the sixth day of the cycle were considered if they were not affected by a disturbance (e.g., disturbed sleep, illness). The third consecutive day of high temperature, above the cover line, was considered the day for entry into the postovulatory phase.

Ultrasound investigations. Serial transvaginal ovarian ultrasound scans with follicle measurement were performed by a single physician per center. Ovarian scanning started on the first day women observed cervical mucus or when an LH surge was detected by LH home tests (Quidel), whichever ultrasound. This is in line with other studies describing the fertile window using the lifespan of spermatozoa and of the ovum as the limiting factors (5, 6) (i.e., the number of days of the BFW would be limited by the number of days of spermatozoa survival).

In the context of fertility awareness-based methods, another fertile window has long been defined: the clinical fertile window (CFW) (7, 8). This window is clinically identifiable by self-assessment of the cervical mucus. It is well known that the cervix acts as a valve, facilitating transport of sperm when the cervical mucus is fluid and inhibiting transport of sperm when the cervical mucus is sticky (9–11). The presence of the cervical mucus felt or seen by the woman at the vulva is the main observable symptom to define the CFW. The CFW begins on the first day of this discharge. The peak day is defined as the last day on which the mucus is observed to be clear, slippery, or stretchy (see Materials and Methods for a detailed definition). The end of this CFW takes place the fourth day after the peak symptom of the mucus (7).

Alternatively, the CFW ends on the third day of high temperature established using the basal body temperature (BBT) rules (12). The CFW, unlike the BFW, is not defined by the lifespan of spermatozoa but by the opening of the cervix as identified by cervical mucus changes. This article does not attempt to assess the impact of these signs on pregnancy rates but to initially assess their validity in relation to ovulation.

The identification of the CFW has been used for a variety of applications, including assisting couples wanting to conceive (13, 14). Mistiming of the fertile window has a significant impact on conception rates (15). Identifying the fertile window may help couples to optimize their chance of conception (15, 16) but also to choose optimal days for medical investigations (17). To apply this recommendation in clinical practice it is necessary to have an estimation of the exact sensitivity and specificity of these clinical signs.

In the present study we tested three scenarios to define the CFW: [1] beginning the first day of any cervical mucus and ending the fourth day after peak mucus (see Materials and Methods for a detailed definition); [2] beginning the first day of any cervical mucus and ending the third day of high BBT; or [3] beginning the first day of peak mucus and ending on the last day of this type of mucus. These three scenarios are correlated with daily ultrasound scans and hormonal profiles, the latter correlation done as secondary analysis to provide useful clinical information on different markers of ovulation. In the mid–1990s a large observational study was carried out on normally fertile women, which included ultrasound-confirmed ovulation, daily urine hormone measurements, and self-assessment of cervical mucus and BBT. Because of legal–commercial disclosure agreements, the results regarding the window of fertility were not able to be published until now.
came first. Scanning was performed every other day until a follicle reached 16 mm and then daily until evidence of ovulation. Details concerning ultrasound investigations were previously published (20). The estimated day of ovulation as determined by ultrasound was defined as the day of maximum follicular enlargement, followed the next day by evidence of rupture.

**Hormonal assays.** The women collected daily samples of early morning urine for quantitative analysis of estrone-3-glucuronide (E1-3-G), pregnanediol-3α-glucuronide (PDG), LH, and FSH. The aliquots were frozen at −20°C on the day of collection and assayed later for hormone detection using time-resolved fluorometric immunosorbent assays (Delfia, PerkinElmer). All the assays were run in duplicate, averaged, and adjusted for creatinine. As suggested many years ago by Collins et al. (21), the ratio of values for E1-3-G to PDG was calculated.

**Definitions of the BFW and the Ovulation Window**

**BFW based on the ultrasound-identified day of ovulation.** The BFW fertile window was defined as a 6-day period including the ultrasound-identified day of ovulation (US-DO). This definition is based on the Wilcox estimation (4). It should be noted that the ovulation day used in the present study is the US-DO, but in the original study (4) the luteal-transition day was used as the presumed ovulation day. In a previous study (22) we compared the ultrasound day of ovulation with the reference day on the basis of hormones (luteal transition): the luteal transition differs sometimes from the ovulation day as per ultrasound, giving a range of US-DO ±1 day in 72% of the cycles.

**Ovulation window.** The 2 last days of the BFW (i.e., the day before and the day of ovulation diagnosed by ultrasound [the US-DO]) is referred to as the ovulation window (OW).

**Tested Definitions of the CFW**

The CFW was tested with three different scenarios. In the first scenario (CFW-mucus), the CFW began on the first day of any mucus felt or seen at the vulva and ended on the fourth day (excluded) after the peak symptom (2). The second scenario (CFW-BBT) began in the same way as the first day of any mucus and ended on the third day (excluded) of high BBT (3). The third scenario (CFW-peak-mucus) began on the first day of peak mucus (Colombo score 4: wet, slippery, or stretchy) felt of seen at the vulva and ended on the last consecutive day of peak mucus.

**Outcome Criteria**

The sensitivity and the specificity of the CFW in relation to the 6-day BFW were identified in the three CFW scenarios. In each scenario, sensitivity was based on having at least 1 day of the biological window identified clinically within the proposed scenarios. Specificity calculation was based on the number of those additional days that, identified by the proposed signs, fell outside (before or after) the BFW. In narrower criteria, it was also calculated with only those additional days before the BFW.

Similarly, each scenario was tested against the OW by similar criteria. Sensitivity for the OW was based on having at least 1 day of the OW identified by the scenarios. Lack of specificity was based first on the number of extra days outside the OW; then we also calculated the proportion of cycles with extra days only before beginning of the CFW.

**Statistical Analyses**

A description of the length of the clinical windows in days was made using mean, minimum, and maximum values. The distribution of the length was shown graphically.

The quality of the clinical window to identify the BFW and the OW was assessed using sensitivity (proportion of the cycles with at least 1 positive day during the BFW and the OW) and the lack of specificity (expressed as the number of positive days before or after the BFW).

The geometric mean of hormonal levels, 15 days before and 5 days after US-DO, were calculated and presented graphically. A multilevel (days within cycle, cycles within women) analysis of variance was used to test the difference of these levels according to the mucus observation (type 1, 2, 3, or 4).

All statistical analyses were performed using R software (version 3.0.0, 2013; The R Foundation for Statistical Computing). A P value <.05 was considered statistically significant.

**RESULTS**

**Demographic and Cycle Characteristics**

Participant and cycle characteristics have been described previously (23). In 283 of the 326 monitored cycles it was possible to confirm ovulation by ultrasound, and thus possible to identify the BFW. A systematic daily notation of mucus observation was available in 226 cycles out of 283 (80%), with a determination of the peak symptom in 191 (67%), and the British Life Assurance Trust (BLAT)-World Health Organization (WHO) rule to read the BBT was applicable in 244 (86%) of them (Supplemental Fig. 1, available online). To identify both the beginning of the CFW-mucus and the end of the CFW-mucus fertile window, the daily notation of mucus observation and the peak symptom were both necessary, limiting the analysis to 132 cycles. To identify the beginning of the CFW-BBT, the daily notation of mucus observation and the BBT were both necessary, limiting the analysis to 166 cycles. If the mucus notation was unclear or missing 1 day, from the onset of mucus to the fourth day after the peak day, the cycle was excluded from the analysis of the mucus-mucus clinical window. The same restriction was not needed for the mucus-BBT clinical window: in that case the onset of mucus and the BBT entry into the postovulatory phases were sufficient. This is the reason there is a higher number of mucus-BBT cycles than mucus-mucus cycles.

**Description of the CFW**

The mean duration of the CFW identified by any type of mucus (i.e., CFW-mucus and CFW-BBT) was 11 days, but the mean duration of the CFW-peak-mucus window was 4 days. The first and third quartile range (the 25th percentile and the 75th percentile) was approximately 9–12 days for...
CFW-mucus and CFW-BBT and only 2–5 days for CFW-peak-mucus (Fig. 1, Table 1).

**Sensitivity and Specificity**

At least 1 day of the BFW was found within the CFW-mucus and CFW-BBT (100% of the cycles) and for the CFW-peak-mucus in 96% of the cycles (Fig. 2). There was a mean of 11 presumed clinically fertile days with CFW-mucus and CFW-BBT scenarios. In the CFW-peak-mucus group there were only 4 presumed clinically fertile days. Indeed, the onset of the fertile windows defined by CFW-mucus, CFW-BBT, and CFW-peak-mucus preceded the actual BFW by 2, 2, and <1 day(s), respectively.

Similar trends were observed for the detection of the 2-day ovulation-window (the day before and the ovulation day): the CFW-mucus, CFW-BBT, and CFW-peak-mucus included at least 1 day of the OW in 98%, 99%, and 88% of the cycles, respectively. The CFW-mucus, CFW-BBT, and CFW-peak-mucus preceded the actual OW by 5, 5, and 1 day(s), respectively.

In a further analysis, all 6 days of the biological window (i.e., the 6-day fertile window) were included within the mucus-mucus clinical window in 69% of the cycles, within the mucus-BBT clinical window in 72% of the cycles, and within the peak mucus clinical window in only 6% of the cycles. All 2 days of the OW were contained within the mucus-mucus clinical window in 98% of the cycles, within the mucus-BBT clinical window in 99% of the cycles, and within the peak mucus clinical window in 58% of the cycles.

As a clinical comparison, in the standard days method (SDM), women with regular menstrual cycles between 26 and 32 days long can use the SDM to prevent pregnancy by avoiding intercourse on days 8 through 19 of their cycles (24). A total of 219 cycles met the criteria (between 26 and 32 days long). In all the cycles, this 8–19-day period included the BFW. The SDM overclassified the number of fertile days between 4 and 11 days. The SDM CFW preceded the actual BFW by 2 days between 1 and 11 days.

**Hormones and Mucus**

As shown in Supplemental Figure 2, LH and FSH did not fully correlate with the mucus observed before ovulation. On the other hand, both E1-3-G and PDG significantly \((P < .05)\) correlated with any type of mucus observed. Estrone-3-glucuronide correlated with mucus before and after ovulation, and PDG correlated with mucus immediately before, and the days following ovulation. Additionally, the ratio of daily E1-3-G/PDG \((P < .05)\) correlated with mucus changes to a greater degree.

**DISCUSSION**

In this study we have demonstrated that, when perceived accurately, peak mucus can be a very useful clinical sign to...
identify both the BFW and the ovulatory window. The role of mucus in human conception was already known as early as the mid-19th century (25, 26). Many studies have evaluated the use of clinical markers to help couples achieve pregnancy. Dunson et al. (27) found that nearly all pregnancies occur from intercourse that take place in the 6-day window ending with the BBT-determined day of ovulation. This 6-day period can be considered to be the BFW. Nevertheless, Bigelow et al. (28) concluded that mucus characteristics on the day of intercourse provide a clinically important predictor of the probability of conception independent of knowledge of the timing of ovulation. They concluded that changes in mucus quality across the fertile interval predict the observed pattern in the day-specific probabilities of conception. It was suggested that, to maximize the likelihood of conception, intercourse should occur on days with optimal cervical mucus quality, as observed in vaginal discharge. Our results have confirmed the high sensitivity of clinical markers to identify the BFW, as well as the ovulation period. The identification of the BFW by the observation of any type of mucus

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Average duration of the proposed windows (range)</th>
<th>No. of days outside the BFW, before or after (range)</th>
<th>CFW beginning before BFW, % (95% CI)</th>
<th>Sensitivity, a % (95% CI) [perfect sensitivity]</th>
<th>Identification of the OW</th>
<th>No. of days outside the OW, before or after (range)</th>
<th>CFW beginning before OW, % (95% CI)</th>
<th>Sensitivity, a % (95% CI) [perfect sensitivity]</th>
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</thead>
<tbody>
<tr>
<td>Mucus-mucus clinical window</td>
<td>10.58 (6–19)</td>
<td>5.11 (2–13)</td>
<td>62 (54–72)</td>
<td>100 [69]</td>
<td>Identification of the OW</td>
<td>8.6 (4–17)</td>
<td>99 (97–100)</td>
<td>98 (94–100)</td>
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<td>(n = 132)</td>
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<tr>
<td>Mucus-BBT clinical window</td>
<td>10.99 (2–25)</td>
<td>5.39 (0–21)</td>
<td>63 (56–71)</td>
<td>99 (96–100) [72]</td>
<td>Identification of the OW</td>
<td>8.9 (0–23)</td>
<td>98 (96–100)</td>
<td>99 (96–100)</td>
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<td>(n = 166)</td>
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<tr>
<td>Peak mucus clinical window</td>
<td>3.78 (1–12)</td>
<td>1.03 (0–6)</td>
<td>9 (3–14)</td>
<td>96 (91–99) [6]</td>
<td>Identification of the OW</td>
<td>2.2 (0–10)</td>
<td>61 (52–69)</td>
<td>88 (81–93)</td>
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<td>(n = 132)</td>
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<tr>
<td>Note: a Sensitivity: at least 1 day of the biological window identified clinically within the proposed scenarios.</td>
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**FIGURE 2**

Frequency of identified days as the CFW in accordance to the three scenarios: [3] any type of cervical mucus (CFW-mucus); [3] mucus and BBT (CFW-BBT); and [3] peak mucus only. (A, B, C) Grey lines represent frequencies outside the BFW, and red lines show frequencies inside the BFW. (D, E, F) Grey lines show frequencies outside the OW, and red lines represent frequencies inside the OW. Taller grey bars are a sign of lack of specificity; taller red bars are a sign of good sensitivity.

is perfectly sensitive. But this signs lacks specificity, with an average of 11 fertile days. For this reason, we suggest the use of peak mucus for this goal, given its high sensitivity for the fertile window (96%) and OW (88%). As a note of caution, 80% of the cycle lengths were between 25 and 32 days. Our estimation of sensitivity and specificity of the CFW for shorter or longer cycles may be an overestimation. More research is warranted to further elaborate on this.

Natural family planning methods have been designed for maximum sensitivity, at the expense of specificity, because they are typically for couples who are avoiding pregnancy. In this context, sensitivity is of utmost importance to avoid unintended pregnancy, and specificity is less important. However, for couples trying to conceive, the situation is reversed: specificity is more valuable than sensitivity. This study demonstrates that the estrogenic mucus observations (peak mucus) obtain much better specificity while retaining good sensitivity for the purpose of trying to conceive.

If the objective is to pinpoint the most fertile days biologically, which would be relevant for trying to conceive, then a 4-day window rather than a 6-day window might be more appropriate. If the objective is to identify the day of ovulation for timing investigations, then doing analyses for the day of ovulation might be more appropriate. Supplemental Table 1 shows the sensitivities and specificities if the biological window were limited to 4 days and the OW were limited to the ovulation day.

It is important to mention that the BFW may not be exactly 6 days. Wilcox et al. (4) noted they could not exclude a probability of pregnancy of up to 13% outside the window, given their data. Other studies (see, for example, references 2 and 27), have suggested a somewhat variable fertile window, narrower for couples with subfertility.

The results of the daily fecundability studies (2, 18) have shown an increase of the probability of conception during the last 3 or 4 days of the fertile period: this is sometimes used as evidence in favor of a limited fecundability of “older” spermatozoa.

Additionally, fertility awareness-based methods are based on the absence of sexual intercourse during the period approaching ovulation and the ovulation period. Their effectiveness (29) can be used to support the concept of low fecundability of older spermatozoa.

Bigelow et al. (28) and others (13, 14, 16, 17) showed that the quality of the mucus observed by the woman on the day of intercourse is an important predictor of the probability of conception independent of knowledge of the timing of ovulation. The increase of the probability of conception during the 3 or 4 days before ovulation might be at least partly explained by the quality of mucus (9–11, 30, 31), limiting the evidence in favor of a decreased probability of conception by older spermatozoa. It could be important to give more consideration to the quality of mucus observed by the woman in the context of an infertility diagnosis (32) and treatment (33, 34), whatever the physiologic interpretation of these observations.

The feasibility of learning the mucus sign accurately has been recently confirmed (35): 92% of women identified presumed ovulation within ±3 days using the clinical observation of cervical mucus. This does not require extensive instruction, and their results were based on a basic written brochure.

In our study the determination of the peak symptom was available in 67% of the cycles. This may be interpreted as a sign of difficulty to identify the peak mucus. However, this lack of information is more probably due to the spurious burden occasioned by the amount of data collected during this study: observation of mucus and BBT, but also collection of urine each day and blood collections twice a month, as well as ultrasound and several dipsticks. Peak mucus was recorded at least 1 day of the cycle in 258 of 283 cycles (91% sensitivity). A higher motivation is needed to be rigorous enough to benefit from this observation. However, women trying to conceive may be willing to proceed with this method.

Porucznik et al. (35) reported on the aptitude of women to determine the likely day of ovulation based on daily observations of cervical fluid. A total of 58 women contributed to 147 cycles. Seventy-two percent of the women did not use observation of the mucus before entry into the study. Among all cycles in which an estimated day of ovulation was recorded by women using the “last fertile sign” algorithm (n = 110), participants selected the correct day of ovulation in comparison with the expert-selected “last fertile sign” algorithm in 76% of cycles, ±1 day in 82% of cycles, ±2 days in 87% of cycles, and ±3 days in 93% of cycles.

Our results provide strong evidence that in clinical settings, instruction in the observation of mucus at the vulva as a clinical surrogate marker of ovulation may help couples in accurately identifying ovulation. This practice would provide additional tools in the management of subfertility, especially because the timing of the fertile window can be highly unpredictable, even if their cycles are regular. Moreover, it has been shown that indicators of fertility such as self-observed cervical mucus and urinary E1-3-G and LH levels with a fertility monitor enable women and their clinicians to time hormonally sensitive clinical tests and treatments in relation to phases of the menstrual cycle (33, 36). Our results also emphasize the utility of peak mucus in identifying ovulation, which confirms previous findings (34). The identified days are particularly appropriate for timing tests and procedures close to ovulation.

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Flow diagram showing inclusion and exclusion criteria. WHO-BLAT: Rule used to identify the first day of the postovulatory unfertile period of the cycle, using BBT.

SUPPLEMENTAL FIGURE 2

Geometric mean of hormonal levels, comprising 15 days before and 5 days after US-DO, in accordance to the type of observed mucus.

**Supplemental Table 1**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Identification of a 4-day BFW</th>
<th>Identification of a 1-day OW</th>
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<tbody>
<tr>
<td></td>
<td>No. of days outside the 4-day BFW, before or after (range)</td>
<td>CFW beginning before the 4-day BFW, % (95% CI)</td>
</tr>
<tr>
<td>Mucus-mucus clinical window (n = 132)</td>
<td>6.65 (3–15)</td>
<td>85 (78–91)</td>
</tr>
<tr>
<td>Mucus-BBT clinical window (n = 166)</td>
<td>6.97 (0–21)</td>
<td>87 (81–92)</td>
</tr>
<tr>
<td>Peak mucus clinical window (n = 132)</td>
<td>1.39 (0–8)</td>
<td>27 (19–35)</td>
</tr>
</tbody>
</table>

a Sensitivity: at least 1 day of the biological window identified clinically within the proposed scenarios.