COVID-19-Outbreak Response combining E-health, Serolomics, Modelling, Artificial Intelligence, and Implementation Research

WP III – Task 3	**By using methods of social sciences, study the feasibility of complementing SORMAS with online respondent-driven detection for enhanced case finding and increased knowledge on contact networks that permit transmission of COVID-19**
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Report on the feasibility of online respondent-driven detection, including a roadmap for implementation in practice

0. PUBLIC SUMMARY (SOCIETAL IMPACT)

Contact tracing can reduce the spread of diseases such as COVID-19. However, during large outbreaks public health services may lack the resources to effectively perform contact tracing. In this work package of the CORESMA-project, we investigated if and how this may be addressed by shifting some tasks that are normally performed by public health professionals to patients (cases) and their contacts, using digital tools (which we refer to as *respondent-driven detection tools,* or *RDD-tools*).

We conducted 17 interviews and surveyed 641 public health professionals involved in COVID-19 contact tracing in the Netherlands. We also systematically investigated international scientific literature on the topic. We found that professionals are, overall, positive about more actively involving cases and their contacts in tasks like identifying, notifying, and monitoring contacts. The beliefs that this approach would make contact tracing more feasible and efficient, that cases and contacts may be more willing to participate in contact tracing when given more autonomy, and that cases and contacts can sufficiently be supported in contact tracing without direct (personal) contact with a professional were important considerations for professionals. Although we conducted our studies in the Netherlands and in the context of COVID-19, international scientific literature suggests that RDD-tools may be of added value in a wide variety of settings, also including resource-poor and non-western contexts, and for communicable diseases other than COVID-19.

Based on the views and needs of professionals, we developed a roadmap for the development and implementation of RDD-tools to enhance contact tracing during future (large scale) outbreaks of communicable diseases. In the roadmap, we outline how RDD-tools can be integrated with 'traditional' contact tracing (both from a technical perspective and regarding guidelines and protocols), in different ways and under different circumstances. In future research we will focus on understanding the views and needs of citizens regarding more actively participating in contact tracing, using digital tools. Their views and needs also need to be incorporated for successful implementation of RDD-tools. In addition, we will use RDD-tools on a small scale in a more 'real-life' situation, to get a better understanding of the advantages and limitations of RDD-tools in practice.

1. BACKGROUND

Contact tracing (CT) has been a core intervention in the global public health response to the SARS-CoV-2 (COVID-19) pandemic and other outbreaks of communicable diseases. The primary aims of CT are to identify and reach contacts of individuals with a confirmed COVID-19 infection (i.e., index cases), to notify them of their exposure-risk and inform them of what measures may be needed to prevent further spread of the pathogen, such as testing and quarantine. If contacts subsequently also test positive for COVID-19, they are requested to isolate for the remaining duration of their infectious period, and the CT-process is repeated, and so forth. In addition, the (epidemiological) data collected through CT are important for knowledge generation about - and surveillance of the virus.

Traditionally, CT is facilitated by public health professionals (PHPs), who work for public health services (PHS). The execution of CT may differ between countries, but typically consists of several stages (1):

- First, after a positive test result is communicated to PHS, a PHP interviews the index case, usually by phone, to collect epidemiologically relevant (health) data and identify individuals who have been in close physical proximity to the index case, in the *contact identification* stage
- Second, in the *contact notification stage*, a PHP notifies and informs the index case's contacts
- Third, in the *contact monitoring* stage, contacts are monitored by PHPs (e.g., through a phone call every x-number of days) to oversee their health, and to advise on – or organize adequate measures, if necessary

However, under pandemic circumstances, with a relatively high – and increasing daily caseload, PHS may not have sufficient human resources at their disposal to effectively facilitate CT. Consequently, PHS may have to prioritize which index cases and contacts they target, and/or stop the execution of parts of the CT-process. This potentially makes CT less comprehensive (in the sense that fewer index cases and contacts are reached and informed) and/or slower, allowing more infections to remain undetected and spread further through the population (2).

1.1. Online respondent-driven detection (RDD)

Online respondent-driven detection (RDD) is an innovative 'self-led' approach to case finding, that may enhance CT and offer potential solutions to resource-related issues in 'traditional' CT, especially during large scale outbreaks or under pandemic conditions (3, 4). With RDD, tasks in CT that are normally performed by PHPs are shifted to cases and their contacts, using digital tools. For example, index cases themselves collect their personal (health) data and identify their contacts through an online 'CT-questionnaire' in the contact identification stage. Index cases then notify and inform their own contacts, through forwarding online information regarding exposure-risk and measures which contacts may need to implement to prevent further spread of the virus in the contact notification stage. Contacts subsequently monitor their own health through an online 'monitoring questionnaire' and take adequate actions, if necessary, in the contact monitoring stage.

With online and direct peer-to-peer communication, and less action from PHPs needed in the identification, notification, and monitoring of contacts, RDD may give index cases and their contacts more autonomy over the CT-process, lower the workload for PHPs, and allow CT to be executed in situations where PHS do not have the resources to do so. Furthermore, RDD may potentially be integrated with case management software routinely used by PHS for CT, such as SORMAS. This could, for example, allow index cases and contacts to share their collected data directly and automatically with PHS, which would further lower the (administrative) workload for PHPs and may enhance the collection of CT-data for monitoring and surveillance purposes.

However, the application of RDD and the degree to which tasks that are traditionally performed by PHPs in CT can be shifted to cases and contacts have not yet been thoroughly and systematically investigated. Importantly, it remains unclear how RDD can be integrated with the 'traditional' approach to CT and what is needed to this purpose (e.g., regarding the development of digital tools to facilitate RDD in practice, and how these can be connected to case management software routinely used by PHPs, such as SORMAS).

1.2. Aims

We investigated if and how RDD may be applied for CT of COVID-19 (and potentially also for other, similar pathogens and outbreak situation), from the perspective of PHPs involved in the execution of CT for COVID-19. More specifically, we investigated the attitudes and needs of PHPs regarding the development and application of 'RDD-tools' (digital tools that allow index cases and their contacts to support the traditional execution of CT by PHPs), for each stage of the CT-process (as previously described). Table 1 provides a comparative overview of the 'traditional' CT-process, executed by PHPs, and CT supported with RDD-tools. Based on our results, we developed a roadmap for the implementation of RDD-tools in the 'traditional' execution of CT by PHPs.

Table 1. Comparative overview of traditional CT executed by PHPs and 'RDD-supported' CT

CT-stage	Traditional CT	RDD-supported CT
Stage 1: contact identification	PHPs interview index cases, usually, by phone, to collect index cases' health and epidemiological data and identify at-risk contacts.	Index cases digitally collect their own (health) information and identify at-risk contacts and share this information with PHS.
Stage 2: contact engagement	PHPs notify and inform contacts of their exposure-risk and give instructions to adequately deal with the situation.	Index cases digitally notify and inform their contacts through forwarding (pre-specified) information and instructions (e.g., via email).
Stage 3: contact monitoring	PHPs monitor contacts every X-number of days to advise on - and monitor symptoms, quarantine/isolation adherence, etc.	Contacts digitally self-monitor their symptoms, e.g., through a daily online questionnaire. If necessary, contacts are prompted to organize necessary measures (e.g., testing when symptoms occur).

2. METHODS AND ACTIVITIES

To investigate PHPs' needs and attitudes regarding the application of RDD-tools for CT of COVID-19, we conducted a sequential exploratory mixed methods study. In Phase 1 of the study, we conducted semi-structured interviews with PHPs who were involved in the execution of CT for COVID-19. In Phase 2, we investigated our findings from Phase 1 in a larger population of PHPs using an online questionnaire, to quantify our qualitative findings. In Phase 3, we conducted a systematic literature search to enhance the generalizability of our results to a broader (international) context.

2.1. Phase 1: exploratory semi-structured interviews

The goals of Phase 1 were to explore the attitudes and needs of Dutch PHPs regarding the application of RDD-tools for CT of COVID-19, to be able to develop a roadmap for the implementation of RDD-tools in the traditional execution of CT by PHPs.

Study population and sampling

Between November 2020 and February 2021, we conducted semi-structured one-on-one interviews (N=17) with Dutch PHPs, who are typically responsible for the execution of CT for COVID-19 in the Netherlands. PHPs were identified and invited through the professional network of the Dutch National Coordination Centre for Communicable Disease Control (LCI) of the RIVM, and via referrals. To gain a broad understanding of PHPs' attitudes and needs, we recruited PHPs with diverse characteristics, such as professional background (i.e., training as public health nurse, or doctor), age, gender, and general experience with CT, for our study. Table 2 provides an overview of characteristics of interviewees. In addition, interviewees were recruited from 12 different PHS, representing all provinces in the Netherlands.

Table 2. Characteristics of interviewees

Characteristics	Interviewees (N=17)
Age, in years (M; IQR)	39 (32-50)

Sex (%) • Male • Female	 4 (23.5) 13 (76.5)
Experience with CT in general, in years (M; IQR)	4 (2.5-9)
Experience with CT for COVID-19, in months (M; IQR)	8 (5-9)
Professional role (%) • PHS Nurse • PHS Doctor	 13 (76.5) 4 (23.5)

***M: Median, IQR: Inter-Quartile Range**

Data collection

We developed an interview guide based on the *Reasoned Action Approach* (5). Due to social distancing measures in place because of the COVID-19 pandemic, interviews were conducted online, using the secure web-conference software Cisco Webex Meetings (V.40.2.14.19). Interviews were recorded, using the audio recording tool available in Cisco Webex Meetings, and took approximately one hour. All interviewees digitally (through a short online questionnaire) gave their explicit consent for the collection, processing, and dissemination of their (anonymized) data before the interview was conducted.

Data analysis

Recordings were transcribed verbatim, after which a thematic analysis was conducted in MAXQDA Plus 2022 (Release 22.0.0). Coding was inductive, and focused on if, and how, RDD-tools may be applied for CT of COVID-19. We performed separate analyses for PHPs' perspectives regarding the application of RDD-tools in the contact identification, notification, and monitoring stages of the CT-process. Based on these analyses, we developed a roadmap for the development and implementation of digital RDD-tools for CT of COVID-19.

Ethical approval

This study was reviewed by the Medical Ethical Committee of the Utrecht University, who exempted this study from the need for a full medical ethical review (reference number: 20-662/C).

Phase 1 products:

- Interview guide to investigate PHPs' attitudes and needs regarding the development and application of digital RDD-tools for CT of COVID-19. Can be found in scientific publication 1
- Scientific publication 1, detailing PHPs' attitudes and needs regarding the application of digital 'RDD-tools' for CT of COVID-19. Published in *BMC Health Services Research* (6)
- Input for the roadmap for the development and implementation of digital RDD-tools for CT of COVID-19. Presented in this report

2.2. Phase 2: online questionnaires

The goal of Phase 2 was to quantitatively investigate our qualitative findings from Phase 1 in a larger group of PHPs in the Netherlands, to assess the (relative) importance of the identified anticipated advantages and challenges of RDD-tools for CT in practice. This allowed us to thoroughly determine directions for the development of RDD-tools, in line with PHPs' perspectives and needs.

Study population and sampling

Between February and March 2022, an online questionnaire was distributed to all PHS (N=25) in the Netherlands. PHS were asked to further distribute the online questionnaire among all individuals (PHPs and temporary CT-employees) involved in the execution of CT for COVID-19. The online questionnaire was developed and distributed using *Respondent-driven sampling* (RDS) software, jointly developed by the RIVM, UMC Utrecht and the Karolinska Institute (Sweden).

Data collection was completed end of March 2022. 641 individuals have completed the online questionnaire. See Table 3 below.

Table 3. Characteristics of questionnaire respondents

Characteristic	Individuals who completed the online questionnaire (N=641)
Age (Mean (SD); Med (IQR))	Mean (SD) = 40.7 (15.4) Med (IQR) = 38 (28-53)
Gender (%)	
• Female	462 (72.1%)
• Male	177 (27.6%)
• Non-binary	2 (0.3%)
Province of employment (%)	
• Drenthe	4 (0.6%)
• Flevoland	15 (2.3%)
• Friesland	71 (11.1%)
• Gelderland	143 (22.3%)
• Groningen	27 (4.2%)
• Limburg	58 (9.0%)
• Noord-Brabant	37 (5.8%)
• Noord-Holland	70 (10.9%)
• Overijssel	70 (10.9%)
• Utrecht	57 (8.9%)
• Zeeland	34 (5.3%)
• Zuid-Holland	50 (7.8%)
• Working at PHS in multiple provinces	5 (0.8%)
Primary occupation at PHS (%)	
• CT-manager/coordinator	25 (3.9%)
• Temporary contact tracer	538 (83.9%)

• PHS-physician	39 (6.1%)
• PHS-nurse	32 (5.0%)
• Other (conversation coach, health educator, policy advisor)	7 (1.1%)
Experience with CT for COVID-19 (time) (%)	
• Other CT experience than COVID-19	15 (2.3%)
• <1 month	13 (2.0%)
• 1-6 months	137 (21.4%)
• 7-12 months	92 (14.4%)
• 1-2 years	384 (59.9%)
Experience with CT for communicable diseases (other than COVID-19) (%)	
• No	588 (91.7%)
• Yes	53 (8.3%)

Online questionnaire

The online questionnaire was developed based on the results of our interviews. For each type of RDD-tool (i.e., RDD-tools 1, 2, and 3, applicable to the contact identification, notification, and monitoring stages in CT, respectively), the qualitatively identified (sub)themes were translated to questionnaire items to which respondents could respond on various 5-point Likert-scales. For each RDD-tool separately, respondents were asked for their intention to use it in practice, if it were available at their respective PHS, and their anticipated (dis)advantages of the given RDD-tool. The online questionnaire also contained general sections regarding respondents' (demographic) characteristics, attitudes towards CT, digitalization of CT, and perspectives on more actively involving cases and contacts in CT. The online questionnaire took approximately 20 – 25 minutes to complete. All respondents gave their explicit informed consent for the collection, processing, and dissemination of their (anonymised) data, through an 'informed consent page' at the start of the online questionnaire.

Data analysis

Using all questionnaire items as predictors, we carried out *random forest* (RF) analyses to identify determinants of PHPs' intention to use RDD-tools 1, 2, and 3, respectively, in CT for COVID-19. RF is a non-parametric machine learning algorithm which predicts an outcome based on a set of variables (7, 8). RF yields a variable importance ranking (VIR) that reflects the relative contribution, or 'importance', of each variable to the accuracy of the predictions. The importance of a variable represents the increase in prediction error, in this study measured in terms of the probability of misclassification (PMC), resulting from the replacement of the variable's value by a randomly chosen value drawn from the variable's distribution. Thus, the greater the increase in the prediction error due to this 'corruption', the greater the importance of the variable.

Using the sample of respondents who completed the questionnaire, we trained three RF-models (one for each RDD-tool). In each model, we used a dichotomized intention variable as the outcome.

Respondents who stated that they would 'definitely' or 'probably' want to use RDD-tool 1, 2, or 3 in CT for COVID-19 were classified as having a 'positive' intention to use the respective RDD-tool. Respondents who stated that they would 'maybe', 'probably not', or 'definitely not' want to use a particular RDD-tool in CT for COVID-19 were classified as having a 'neutral/negative' intention.

For each model, we report the VIR (Appendix B). We assessed the VIRs visually to identify the most important predictors (i.e., determinants of PHPs' intention) for each model. As a general guideline, we considered all predictors above the 'cut' from where predictors start to align vertically to the left side of the VIR to be determinants of PHPs' intention (predictors below this 'cut' have little contribution to a model's performance).

Instead of logistic or linear regression, we chose RF because of its flexibility in dealing with many variables (around 45 per model in our case) and its inherent greater ability to mimic the behavior of the data when based on a large sample (7, 9).

Since the questionnaire contained many items that were derived from qualitatively identified overarching 'themes', we expected that there would be substantial (multi)collinearity among the predictors included in the RF-models. This overlap is also grounded in theories on (health) behavior (9). Although this is not an issue for the performance of the RF-models in terms of their prediction accuracy, it does complicate the interpretation the VIRs for practical purposes. For example, it may not make sense – and it may not be practically possible - to only consider one or two highly ranked predictors, if these are strongly correlated to lower ranked predictors derived from the same (qualitatively identified) concepts or themes. In such a case, it may make more sense to focus on groups, or *clusters*, of relatively highly ranked and related (i.e., correlated) predictors that may be targeted together in the development and implementation of RDD-tools in practice. To identify such clusters, we performed agglomerative hierarchical clustering analyses (10) on the determinants (i.e., strong predictors) identified in each RF-model. See also Appendix C.

Ethical approval

This study was reviewed by the Medical Ethical Committee of the Utrecht University, who exempted this study from the need for a full medical ethical review (reference number: 21-715/C).

Phase 2 products:

- Questionnaire to assess PHPs' intention to use RDD-tools for CT of COVID-19. This will be part of Scientific publication 2
- Scientific publication 2, detailing determinants of PHPs' intention to apply RDD-tools in practice. Submitted to *PLOS Digital Health* (Manuscript title: *Determinants of Dutch public health professionals' intention to use digital contact tracing support tools: a cross-sectional online questionnaire study*)
- Input for the roadmap for the development and implementation of digital RDD-tools for CT of COVID-19. Presented in this report
- Workshop presentation of combined phase 1 and 2 results at *Transmissiedag* in Amersfoort, 2023. Short workshop video available (only in Dutch) at: https://www.rivm.nl/weblog/video-innovatie-in-bco
- Oral presentation of combined phase 1 and 2 results at *World Congress On Public Health* (WCPH) in Rome, 2023 (Abstract title: *'Involving cases and contacts more actively and autonomously in contact tracing through digital tools: a mixed methods investigation among Dutch public health professionals involved in COVID-19 contact tracing'*)

2.3. Phase 3: Systematic literature search

Originally, we intended to conduct our mixed-methods study in two EU-countries, the Netherlands and Germany, to gain a more in depth understanding of the (international) implementation potential of RDD-tools for CT of COVID-19, also considering different case management software systems (including SORMAS) routinely used by PHS, and different CT-protocols and -systems. Though we achieved our goals in the Netherlands, unfortunately we were unable to also perform the study in Germany, despite various efforts over the period of one year. For example, with the help from our German colleagues of the HZI, leading the CORESMA-project, we established contact with five PHS from the North-Rhine Westphalia region in Germany, some of which used (or considered using) SORMAS. However, we only managed to conduct two (pilot) interviews with PHPs from Germany. We believe that the high workload at German PHS played an important role in this regard. In addition, we suffered significant delays in the process of obtaining ethical approval for our interviews in Germany from the medical ethical committee of the *Medizinsche Hochschule Hannover*, which took over six months to complete. As a result, we were only able to focus on the Dutch context.

Another option that was explored was to conduct a comparative study in Ivory Coast (Côte d'Ivoire), where SORMAS was implemented as part of the CORESMA project. However, the implementation of SORMAS in Ivory Coast was still ongoing and the software was not routinely used by professionals at that time. In addition, we expected that there would be a significant risk of delays, also considering the difficulties in implementing SORMAS in Ivory Coast. As such, we concluded that it would not be feasible to conduct a comparative study in Ivory Coast within the remaining timeline of our study.

As an alternative approach, the CORESMA project partners, in agreement with members of the EC-review committee, decided to conduct a systematic literature search to provide an overview of what types of digital tools that facilitate active and autonomous involvement of cases and contacts in CT are currently used/considered. We aimed to identify where (i.e., in what countries) such digital tools are applied and what barriers and facilitators (also related to the acceptability and feasibility) are commonly reported in relation to their implementation and application, from the perspectives of different stakeholders (e.g., PHPs or index cases and contacts). This approach would give us insights into the transferability and generalizability of our results from the Dutch context to other (EU) countries.

<u>*Focus of the systematic literature search*</u>

In our search, we focused on countries worldwide, and included digital tools that facilitate active and autonomous involvement of cases and contacts in CT used in the context of CT for COVID-19, as well as for other communicable diseases that spread through (in)direct physical contact between individuals (e.g., tuberculosis and sexually transmitted infections (STI's)). Our search included needs assessments, evaluations, implementation studies and pilot studies. We specifically focused on digital tools that facilitate manual (in the sense that individuals rely on their own memory and input) contact identification, notification, and/or monitoring, in the context of CT. Therefore, we excluded studies focusing on digitally 'automating' the CT-process, such as Bluetooth- or GPS-based proximity recording apps. In addition, we excluded studies focusing on digital tools for purposes other than CT, such as symptom trackers used solely for syndromic surveillance.

<u>*Search strategy and article selection*</u>

Between August and September 2022, we searched PubMed for articles that meet the above outlined inclusion criteria published in the past 10 years (2012 – 2022). Reference lists of included articles were checked to see if potentially relevant articles were missed in our initial search.

The following search terms were used:

- Contact tracing:

((contact OR case OR symptom) AND (finding OR notification OR identification OR investigation OR tracing OR monitoring OR referral OR management))

- Digital tools:

((apps) OR (app) OR (applications) OR (technologies) OR (mhealth) OR (telemedicine) OR (tele medicine) OR (telehealth) OR (internet) OR (electronic) OR (web-based) OR (digital) OR (eHealth) OR (digital tool) OR (questionnaire) OR (survey) OR (mobile) OR (online) OR (diary))

- Study type:

(attitude OR intention OR perspective OR needs OR evaluation OR pilot OR feasibility OR needs assessment OR implementation)

Two researchers (YH and RB) independently screened the titles and abstracts of all unique records identified. The full text of each selected record was screened by YH and RB, considering the above outlined eligibility criteria. The selected articles were critically reviewed by YH and RB and 'inclusion mismatches' between authors were discussed until consensus is reached. Finally, remaining articles were included in the review for data extraction.

Data extraction and analysis

A data extraction table was developed to collect and organize the data from included articles. The table included topics such as: study title, year of publication, country in which the study took place, study design, study population, description of the digital tool used in CT, stage in CT at which the digital tool is aimed (i.e., contact identification, notification, or monitoring), interaction/integration of digital tool with public health services (i.e., was the tool completely or partly 'self-led' from the perspective of cases/contacts), disease(s) of interest, main findings, reported barriers/facilitators of the study and the digital tool, suggestions on how the digital tool of interest may (not) benefit CT.

An overview was created of what types of digital tools that facilitate active and autonomous participation of cases and/or contacts are used in CT, for what purposes, in which settings, and what common barriers/facilitators are. Results were compared to findings from Phases 1 and 2, to gain insights into common barriers and facilitators, and therewith the international implementation potential of RDD-tools. Findings were integrated with scientific publication 2. A short description is given in this report. An overview of the included studies can be found in Appendix A.

Ethical considerations

No ethical issues were foreseen regarding the systematic literature search.

Phase 3 products:

- Results from the systematic literature search were incorporated in scientific publication 2, where we included a discussion section on the international implementation potential of RDD-tools for CT for COVID-19 – and other communicable diseases that transmit via (close) contact between individuals. The main findings are also described in this report (see also Appendix A).

3. MAIN FINDINGS FROM PHASES 1, 2, and 3

3.1. PHPs' general perspectives and needs regarding the application of RDD-tools for CT of COVID-19

The following summary of findings and recommendations are based on Phase 1.

Overall, we found that Dutch PHPs have a *positive* attitude towards the application of RDD-tools for CT of COVID-19 in general. PHPs were more positive towards the application of RDD-tools in the contact identification and monitoring stages of the CT-process, compared to the contact notification stage. This was related to the degree to which advantages and challenges of RDD-tools were anticipated to manifest in the different stages of the CT-process; advantages of RDD-tools were anticipated in all stages, but the challenges were mostly foreseen in the contact notification stage.

Important anticipated advantages included:

- CT can be executed faster and with less work for PHPs
- Additional options for index cases and contacts to participate in CT, with more autonomy over the CT-process
- Potential to improve the quality of the collection and administration of CT-data (e.g., for surveillance)

Important anticipated challenges included:

- PHPs have fewer opportunities to ensure adequate (i.e., complete and timely) execution of the CT-process
- PHPs have fewer opportunities to support index cases and contacts in CT

Notably, the circumstances under which CT is performed also play an important role in PHPs' attitudes towards RDD-tools. PHPs indicated that they are more open towards RDD-tools when they have limited opportunities to facilitate CT themselves, and with relatively motivated and digitally skilled index cases and/or contacts. In addition, it was felt that in relatively complex and/or impactful settings (such as outbreaks in care facilities, or when outbreak control and knowledge generation critically depend on CT), the responsibility in CT should remain mostly with PHPs.

Several needs were identified regarding the development and application of RDD-tools for CT of COVID-19. Needs were mostly related to overcoming the anticipated challenges of RDD-tools, whilst maintaining their benefits. Overall, needs included:

- Opportunities for PHPs to remain personally involved in the CT-process, to guide the execution of CT – and support index cases and contact persons where necessary
- PHPs should receive indications of usage of RDD-tools by index cases/contacts in the CT-process, so that PHPs can undertake additional action if necessary
- Connection between RDD-tools and case management software routinely used at PHS (e.g., SORMAS), to facilitate automatic transfer of data collected by index cases/contacts and PHS case management software
- RDD-tools should be easy-to-use and low-effort for index cases, contacts, and PHPs
- RDD-tools should be developed with adequate data security and privacy protection features

3.2. Determinants of PHPs' intention to use RDD-tools in practice

The following summary of findings and recommendations are based on Phase 2.

Based on the results from Phase 1, we developed and distributed an online questionnaire to identify determinants of PHPs' intention to use three types of RDD-tools, one for each stage of the CT-process. We used RF-analyses to identify important determinants. See Figures B1, B2, and B3 in Appendix B for a detailed overview.

Most questionnaire respondents had a positive intention towards using RDD-tools for the identification (64,5%), notification (58%), and monitoring (55.2%) of contacts. RF-models were able to correctly predict the intention of 81%, 80%, and 81% of respondents to use RDD-tools for the identification, notification, and monitoring of contacts, respectively.

We found that PHPs' intention to use RDD-tools 1, 2 and 3 (for the identification, notification, and monitoring of contacts, respectively) is dependent on numerous determinants, rather than a few top-determinants. Typically, determinants related to the anticipated impact of RDD-tools on the feasibility and efficiency of CT (speed, workload, difficulty), support for cases and/or contacts, and the degree to which cases and/or contacts may find it pleasant and may be willing to participate in CT using RDD-tools, ranked relatively high. Identified top determinants should be prioritized in the development and implementation of RDD-tools.

We used agglomerative hierarchical cluster analyses (10) to identify larger groups, or clusters of related (i.e., correlated) determinants (as identified through the RF-analyses) that may be targeted together in the development and implementation of RDD-tools, in line with PHPs' needs. See Figures C1, C2, and C3 in Appendix C for a more detailed overview.

We identified and named 3 main clusters of determinants that may be grouped together. These clusters are very similar, and sometimes even identical for all three RDD-tools:

- The first cluster, *'enhancing the feasibility and efficiency of CT'*, includes the workload, speed, and difficulty of CT.
- The second cluster, *'sufficiently supporting and overseeing cases and contacts to ensure adequate execution of CT'*, includes support for cases/contacts and control of PHPs over the CT-process, and variables related to the performance of CT, such as the correctness and completeness of CT-data, the number of contacts identified/notified, and compliance of cases/contacts with CT-measures.
- The third cluster, *'considering the preferences, willingness, and skills of cases and contacts in the application of RDD-tools'*, includes variables related to the pleasantness of CT for cases/contacts, and their willingness and skills to participate in CT with RDD-tools.

In the roadmap (presented later in this report) we provide general suggestions to incorporate these clusters of determinants in the development of RDD-tools 1, 2, and 3.

3.3. International implementation potential of RDD-tools

The following summary of findings and recommendations are based on Phase 3. See also Appendix A.

We identified 577 unique records, of which we screened the titles and abstracts. Of these, 179 were included for full text screening. Based on the full-text screening, 44 articles were included for a more thorough full-text assessment. From the reference lists of these articles, 4 more articles were included. Finally, 33 articles were included for data extraction. See Appendix A for an overview of included studies.

Studies were conducted in a wide variety of countries from Europe, North America, South America, Asia, and Australia, also including resource limited and -rich countries. Most studies focused on STI's or on COVID-19 and concerned partner/contact notification or self-assessment of health status and symptom monitoring. Very few studies explicitly focused on contact identification. Most of the studies described tools that were, at least to some degree, integrated with public health services, meaning that PHPs were usually involved at some point.

In general, we found very similar reasons for RDD-tool development (increasing efficiency/effectiveness of CT, overcoming stigma in partner/contact notification) and benefits/barriers as we found in our study. For example, (personal) support for cases and contacts and considering their preferences, willingness, and skills in the application of RDD-tools is a recurring theme that consistently seems to lead PHPs to consider RDD-tools as an addition to - rather than a replacement of - the 'traditional' CT-approach. In addition, several (evaluation) studies report that RDD-tools can indeed significantly reduce the workload of PHPs and increase the numbers of cases/contacts involved/reached in CT. The epidemiological impact of RDD-tools (e.g., of reducing transmission in a population) remains largely unclear, however. Most studies describe positive attitudes amongst both PHPs and citizens (cases and/or contacts) towards the use of RDD-tools.

Based on our systematic literature search, we conclude that PHPs may have similar perspectives and needs regarding the use of RDD-tools across different countries and in the context of different communicable diseases. Nevertheless, we emphasize that local context (e.g., technological and cultural factors) should always be taken into account in the development and implementation of RDD-tools.

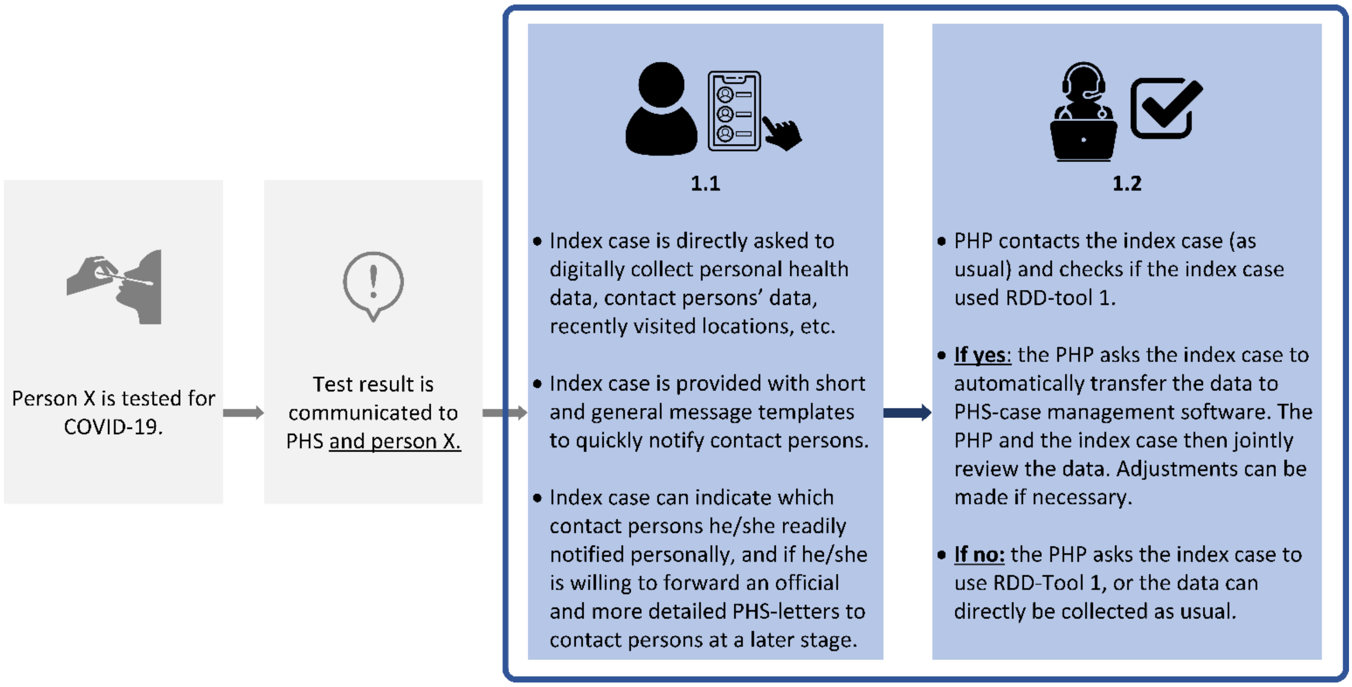
4. ROADMAP FOR IMPLEMENTATION OF RDD-TOOLS IN PRACTICE

Based on the results from Phase 1, 2, and 3 and the internationally increasing interest in - and implementation of digital tools to enhance CT through novel ways of involving index cases and contacts in CT (e.g., Bluetooth-based proximity tracing apps with contact diary functions, such as the mobile application '*Coronawarn'*), we strongly believe that implementation of RDD in public health practice is feasible and beneficial. We propose a 'roadmap' for integrating RDD-tools in the traditional execution of CT by PHPs, including also suggestions to connect RDD-tools to case management software routinely used by PHS (e.g. SORMAS or Go.Data), in a manner that could accommodate PHPs' needs, and could be flexibly implemented with regard to the circumstances under which CT is performed. Note that the proposed roadmap is based on phases 1, 2, and 3 of our study, as described in this report, previous research that we conducted on the same topic (3), and more general insights derived from behavior change methods described elsewhere (11, 12).

4.1. RDD-tool 1: contact identification

Immediately when index cases receive their positive COVID-19 test result, preferably before they are contacted by a PHP, they should be offered the opportunity to use RDD-tool 1 to collect their personal health data and data about their contact persons (see Figure 1).

Figure 1. Recommendations for implementation of RDD-tool 1 in the contact identification stage.

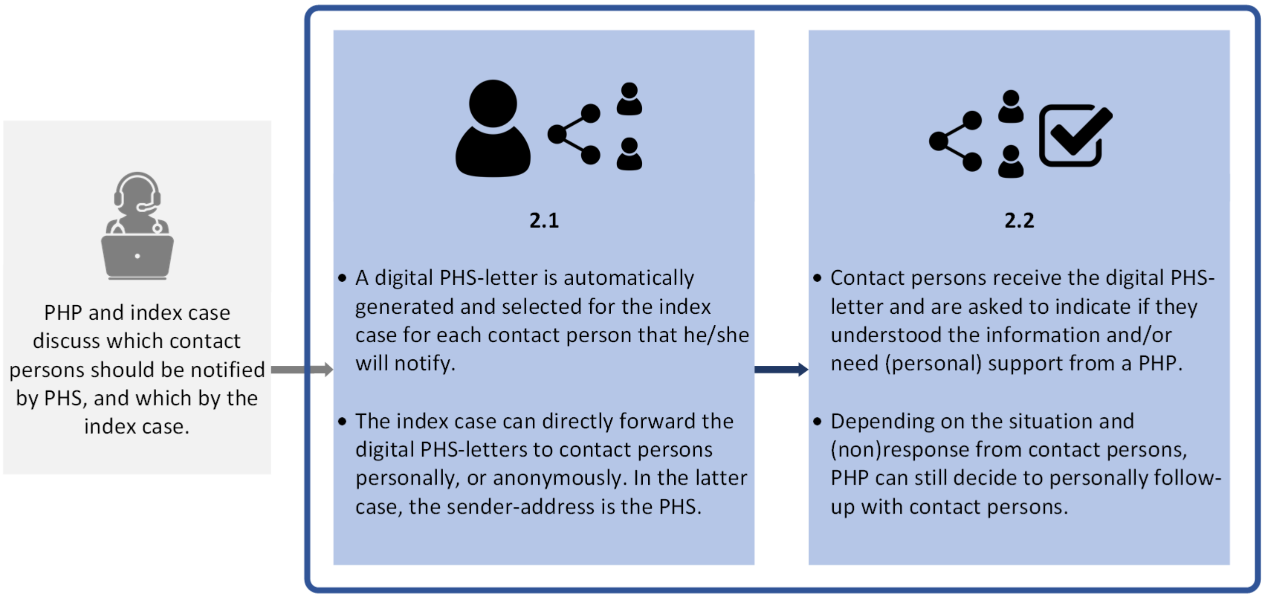


At this stage, index cases could potentially also directly be provided with short message templates containing general warnings and information to copy-past and forward to their contacts, in preparation of the 'official' notification process that follows later. In this case, index cases could also be asked to indicate in RDD-tool 1 which contacts they already notified personally, and/or if they would be able/willing to also forward more extensive PHS-guidelines to contact persons at a later stage. When an index case is then contacted by a PHP, as usual, the PHP first checks if the index case already used RDD-tool 1, or not. If so, the PHP asks the index case to automatically transfer the data to PHS-software. The index case and the PHP can then jointly review the data, to avoid missing data or contacts. If the index did not use RDD-tool 1, the PHP may suggest to the index to still use RDD-tool 1 and continue the CT-interview later, or the data can directly be collected over the phone, as usual.

4.2. RDD-tool 2: contact notification

After contact identification was performed, the PHP and the index case should discuss (and preferably jointly decide), which contacts should be notified by the PHP, as usual, and which contacts by the index through RDD-tool 2 (see Figure 2). For each contact that the index case will notify, an official PHS-letter with tailored CT-guidelines (e.g., based on exposure-risk) should automatically be generated and made available to the index case in RDD-tool 2. Subsequently, index cases can forward the PHS-letters to their contacts personally, or anonymously (in the latter case, the sender could be the PHS).

Figure 2. Recommendations for implementation of RDD-tool 2 in the contact notification stage.

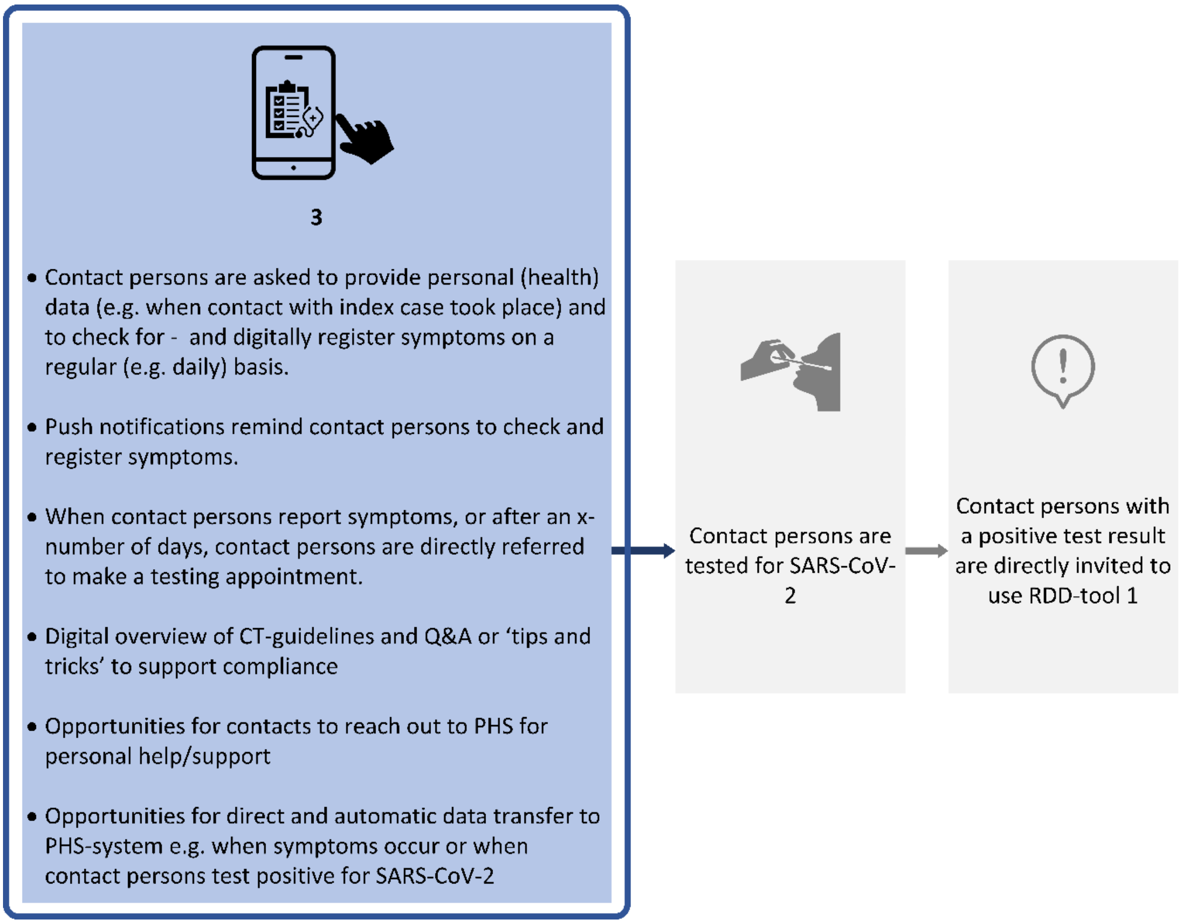


Contact persons who receive a tailored PHS-letter from an index case should be asked to indicate to the PHS if they received and understood the information, and/or need support and would like to speak to a PHP personally. We suggest that this could, for example, be facilitated through a short online questionnaire that contact persons can enter through the PHS-letter that index cases forward to their contacts, or a dedicated PHS e-mail address or phone number. Based on the (non)responses from contacts, PHPs can decide if personal follow-up is still necessary.

4.3. RDD-tool 3: contact monitoring

When contacts are notified (through an index case or by a PHP), they could directly be asked to use RDD-tool 3 to digitally register their symptoms on a regular (e.g., daily) basis (see Figure 3). Push-notifications could be used to remind contact persons to keep using RDD-tool 3. In addition, contact persons should be able to fill out basic personal (health) information, for example when contact with the index case last took place. If contact persons then register symptoms, or an x-number of days (depending on specific guidelines in place) after the last reported contact with the index case, they can directly be forwarded to make an (online) testing appointment at a nearby testing facility.

Figure 3. Recommendations for implementation of RDD-tool 3 in the contact monitoring stage.



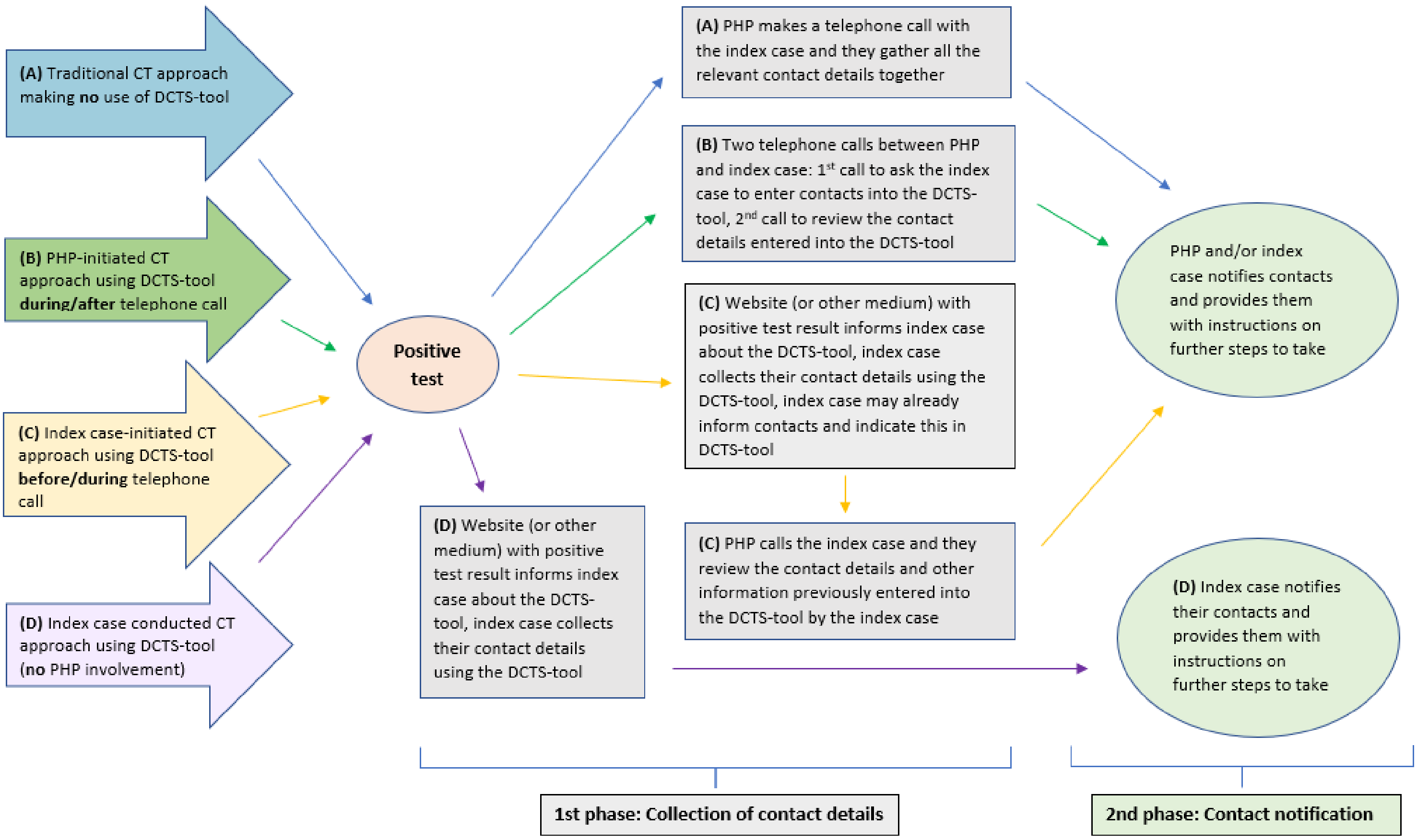
RDD-tool 3 should also contain an overview of CT-measures that need to be followed during the monitoring period (e.g., quarantine). Compliance with CT-measures could be supported and motivated, for example through an interactive Q&A (e.g., a chat robot), or a general overview of frequently asked questions. Potentially, a chat function, or a designated PHS e-mail address, could be included to allow contacts to personally contact PHPs, and vice versa. It should be able for contact persons to automatically share their data with PHS, for example when symptoms occur or after contact persons receive a positive test result. Contact persons who receive a positive test result can immediately be asked to use RDD-tool 1.

4.4. Expanding the roadmap: specifying different levels of citizen involvement in CT.

In addition to our recommended approach to implementing RDD-tools 1-3 as described above (which we consider the most 'optimal' form in general), we may distinguish several other approaches to implementation, with varying levels of autonomy for citizens. These other approaches may, for example, be preferable under different circumstances, such as non-pandemic conditions or for diseases other than COVID-19.

Besides the traditional approach to CT (approach 'A', which is completely led by PHPs), we propose three other approaches (B-D) with increasing levels of citizen autonomy and responsibility. See Figure 4 (see also upcoming paper *'Evaluating the Added Value of Digital Contact Tracing Support Tools for Citizens: Framework Development'* by Baron et al. (2023), submitted to *JMIR Research Protocols*).

Figure 4. Flowchart showing four CT approaches: the traditional approach (A) and three possible approaches (B-D) using RDD-tools, with varying levels of index case involvement: **A**. Traditional CT approach, **B**. PHP-initiated CT approach making use of an RDD-tool, **C**. Index case-initiated CT approach making use of an RDD-tool, **D**. Index case conducted CT approach making use of an RDD-tool. Note that DCTS-tool* = RDD-tool.



**Digital Contact Tracing Support Tool*

In approach B (PHP-initiated CT), the PHP calls the index case to start the CT process. Together they complete a questionnaire to gather relevant demographic and medical details about the index case. The index case is then asked if they are willing to enter their relevant contact details into the RDD-tool, such as a designated website or app. The PHP and index case arrange a new appointment shortly afterwards to review the contacts that have been provided by the index case, to determine whether additional information is needed and to agree on who will inform the contacts and provide them with instructions on further steps to take.

Approach C (index case initiated CT, closely resembles our suggested/preferred approach) may be more efficient for CT (e.g., alleviating the burden experienced by PHPs and increasing the speed of CT), as the index case is made aware of the RDD-tool before the call with the PHP in which the CT process initiated. The designated medium to communicate test results to citizens (such as a website or e-mail) can direct index cases to enter their contact details into the RDD-tool. This information is then ready to be discussed and shared digitally before the call with the PHP. This approach could lead to increased accuracy in contact details (such as telephone numbers), as these will not be conveyed verbally during the phone call. During the call, the provided information can be checked, additional details can be shared, if necessary, and further steps can be discussed.

In approach D using RDD-tools (index case conducted CT), the entire CT process is transferred into the hands of citizens, or at least to a selection of 'low-risk' citizens (e.g., individuals with a low risk of severe health outcomes and/or individuals with low-risk contacts). In this situation, there is no contact at all between the PHP and the index case. The index case independently uses the RDD-tool to help recall and notify relevant contacts of their possible exposure risk and provides contacts with appropriate instructions already programmed in the tool. This could potentially free up time for PHPs to focus on index cases with greater health risks or with limited access to RDD-tools. This approach may be beneficial if the virus variant is very infectious (leading to high numbers of index cases), but relatively less severe, with regard to its effects on morbidity and mortality.

5. DISCUSSION AND NEXT STEPS TOWARDS IMPLEMENTATION OF RDD-TOOLS IN PRACTICE

Though we believe that our findings are important regarding the development and application of RDD-tools, it should be kept in mind that our findings are strongly bound to the Dutch context and to the pandemic phase during the interviews and questionnaires were conducted (e.g., rise of the COVID-19 Alfa-variant, with significant shortages of human resources for CT). It may, for example, be that PHPs' attitudes and needs towards RDD tools differ in settings where pandemic control and knowledge generation more critically rely on CT (e.g., in smaller, isolated, or novel outbreak settings) or in countries with diverging CT-systems and/or -protocols. Similarly, it may be that RDD-tools are perceived by PHPs as less, or differently, applicable in countries with a lower degree of digitalization of the population (in 2018, 98% of Dutch households had access to broadband internet and 84% of the Dutch population had internet access through their mobile devices outside home or work), including several countries where SORMAS is being implemented, such as Nepal and Ivory Coast (where an estimated 38% and 36% of the population were internet users in 2020 and 2019, respectively) (13, 14). Nevertheless, considering the similarities between our results/findings and other studies conducted on RDD-tools (or similar tools) worldwide and in the context of various diseases, we still strongly believe that our results are also relevant for other countries and settings. We suggest that RDD-tools have the potential to be implemented in a wide variety of countries and settings, although local context should always be considered to this purpose.

Our findings are based on PHPs' perspectives, whereas the success of RDD-tools in practice inherently depends on action from index cases and their contacts. Therefore, we believe that additional research is warranted to explore the general public's perspective, attitudes, and needs regarding the application of RDD-tools for CT of COVID-19, similar to how the public's perspectives regarding Bluetooth-based proximity tracing applications were investigated in previous research (15). In another (parallel) project at the RIVM, we are currently conducting several studies among Dutch citizens to this purpose (see also (16)).

The development of RDD-tools requires sophisticated technological implementation of data security and privacy protecting measures, since it is important to PHPs that RDD-tools allow for direct and/or automatic data transfer to case management software routinely used at PHS, such as SORMAS. In addition, RDD-tools should be easily accessible, user friendly, and low-effort for a broad audience. Therefore, we suggest collaborating with public health practitioners, user experience (UX) developers, and digital data security and privacy specialists in the development of these RDD-tools.

In the Netherlands, SORMAS is not implemented. Various other case management systems were used during the pandemic (e.g., HPZone, HPZone light, CoronaCare, GGD Contact). Nevertheless, we would like to stress that our results are sufficiently general, in the sense that they are applicable to CT in different settings, regardless of the specific case management system used. It could, however, be that opportunities and requirements for the specific (technical) integration of RDD-tools may differ between case management systems. This should be taken into account in the interpretation of our results, especially with regards to the (technical) implementation of the proposed roadmap.

We would like to emphasize that our findings are somewhat hypothetical, in the sense that they are based on PHPs expectations - rather than their actual experiences with RDD-tools (since these types of applications are rarely used in the Netherlands). Evaluations of the application RDD-tools in practice are urgently needed. In the near future, we intend to conduct small scale pilot studies in the Netherlands to this purpose.

6. CONCLUSIONS

Based on our results, we believe that it is feasible and beneficial to implement RDD-tools in practice. Dutch PHPs have a positive attitude towards the application of RDD-tools for CT of COVID-19 and anticipate that it can significantly benefit the contact identification, notification, and monitoring stages of the CT-process. Anticipated challenges may be overcome through adequate development and implementation of RDD-tools in the CT-process, including a link for automatic data transfer between RDD-tools and case management software routinely used by PHS. RDD-tools are used in various countries worldwide, including also resource limited and non-western countries, and for a variety of diseases. Internationally observed benefits and challenges appear very similar, although local context should always be taken into account. Based on our results, we proposed a road map for implementation of RDD-tools in practice.

We believe that SORMAS (and other case management software) would especially benefit from – and provides opportunities for integration of RDD-tools, in a manner that allows for bi-directional information transfer between index cases or contacts on the one hand (e.g., through mobile and computer based digital applications), and PHPs on the other. If and how such RDD-tools are then precisely utilised within countries’ CT-systems and -protocols, should be finetuned to local contexts.

Further research is, however, warranted to assess the general public’s attitudes and needs regarding the development of RDD-tools for CT of COVID-19.

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8. LIST OF ABBREVIATIONS

CT: Contact tracing

COVID-19: SARS-CoV-2

LCI: National Coordination Centre for Communicable Disease Control

PHP: Public health professional

PHS: Public health services

RDD: Respondent-driven detection

SORMAS: Surveillance Outbreak Response Management and Analysis System

RF: Random Forest

DCTS-tool: Digital contact tracing support tool

9. APPENDIX A. Articles included for data extraction in systematic literature search.

Title	**Year published**	**Country/countries**	**Disease**(s) targeted	**Status real-life usage (hypothetical/real-life**/prototype**)**	**Type of digital tool**	**Main features of tool (**e.g., partner notification, contact identification, monitoring**)**
Prioritizing COVID-19 Contact Tracing During a Surge Using Chatbot Technology	2022	United States of America	COVID-19	Real-life	Chatbot	Identification/notification/follow-up
Leveraging Polio Geographic Information System Platforms in the African Region for Mitigating COVID-19 Contact Tracing and Surveillance Challenges: Viewpoint	2022	Countries in the WHO African Region	COVID-19	Real-life	Mobile app	Self-assessment/symptom-monitoring)
Private High School Reopened-COVID Mitigation and Clinical Surveillance Using an Internet Application	2022	United States of America	COVID-19	Real-life	Web-based	Self-assessment/symptom-monitoring)
A Web-Based Digital Contact Tracing Strategy Addresses Stigma Concerns Among Individuals Evaluated for COVID-19	2022	United States of America	COVID-19	Hypothetical	Web-based	Contact notification
Feasibility of using a mobile App to monitor and report COVID-19 related symptoms and people's movements in Uganda	2021	Uganda	COVID-19	Real-life	Mobile app	Self-assessment/symptom-monitoring)
Investigating the effective factors of using mHealth apps for monitoring COVID-19 symptoms and contact tracing: A survey among Iranian citizens	2021	Iran	COVID-19	Hypothetical	Mobile app	Self-assessment/symptom-monitoring)
Quality and Adoption of COVID-19 Tracing Apps and Recommendations for Development: Systematic Interdisciplinary Review of European Apps	2021	Europe	COVID-19	Real-life	Mobile app	N/a (all types)

Ethical Implications of eHealth Tools for Delivering STI/HIV Laboratory Results and Partner Notifications	2021	General	STIs/HIV	Real-life/hypothetical	N/a	Partner notification
Health Apps for Combating COVID-19: Descriptive Review and Taxonomy	2021	General	COVID-19	Real-life	Mobile app	Self-assessment/symptom-monitoring/contact notification
Acceptability of Using Geosocial Networking Applications for HIV/Sexually Transmitted Disease Partner Notification and Sexual Health Services	2020	United States of America	HIV/Syphilis	Hypothetical	Mobile app	Partner notification
High willingness to use novel HIV and bacterial sexually transmitted infection partner notification, testing, and treatment strategies among gay and bisexual men	2020	United States of America	HIV/ Chlamydia/ Gonorrhea	Hypothetical	Mobile app	Partner notification
Contact tracing with digital assistance in Taiwan's COVID-19 outbreak response	2020	Taiwan	COVID-19	Real-life	Mobile app/text messages	Self-assessment/symptom-monitoring)
Rapid Deployment of a Free, Privacy-Assured COVID-19 Symptom Tracker for Public Safety During Reopening: System Development and Feasibility Study	2020	United States of America	COVID-19	Prototype	Web-based	Self-assessment/symptom-monitoring)
Protect MSM from HIV and other sexually transmitted diseases by providing mobile health services of partner notification: protocol for a pragmatic stepped wedge cluster randomized controlled trial	2020	China	STIs/HIV	Prototype	Mobile app	Self-assessment/partner notification
Health Observation App for COVID-19 Symptom Tracking Integrated With Personal Health	2020	Japan	COVID-19	Real-life	Mobile app	Self-assessment/symptom-monitoring)

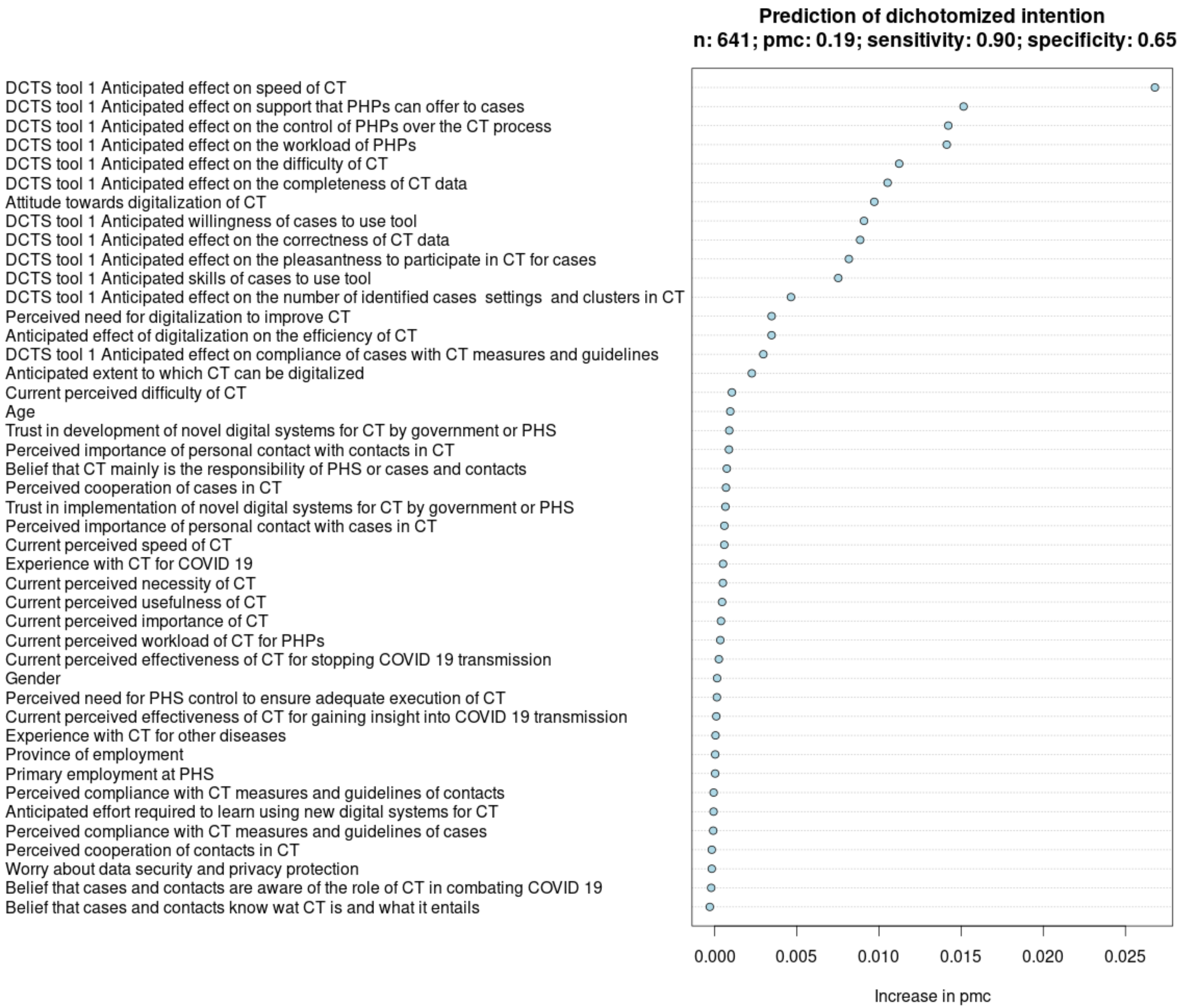
Records: Proof of Concept and Practical Use Study						
Protecting Men Who Have Sex With Men From HIV Infection With an mHealth App for Partner Notification: Observational Study	2020	China	HIV	Real-life	Mobile app/web-based	Self-assessment/partner notification
Case-Initiated COVID-19 Contact Tracing Using Anonymous Notifications	2020	China	COVID-19	Hypothetical	Web-based	Contact identification/contact notification
Personalizing symptom monitoring and contact tracing efforts through a COVID-19 web-app	2020	China	COVID-19	Real-life	Web-based	Contact identification/symptom monitoring
Characteristics and Outcomes of Contacts of COVID-19 Patients Monitored Using an Automated Symptom Monitoring Tool - Maine, May-June 2020	2020	United States of America	COVID-19	Real-life	Web-based	Symptom monitoring
Development and evaluation of an application for syphilis control	2019	Brazil	Syphilis	Prototype	Mobile app	Partner notification
Using electronic communication technologies for improving syphilis partner notification in Chile: healthcare providers' perspectives - a qualitative case study	2019	Chile	Syphilis	Hypothetical	Mobile or web-based	Partner notification
Traditional and Web-Based Technologies to Improve Partner Notification Following Syphilis Diagnosis Among Men Who Have Sex With Men in Lima, Peru: Pilot Randomized Controlled Trial	2018	Peru	Syphilis	Prototype	Web-based	Partner notification
An audit of a novel electronic messaging treatment service for Chlamydia trachomatis at a community pharmacy	2018	United Kingdom	Chlamydia	Real-life innovation	Other (electronic voucher for treatment of STI)	Referral for treatment

Young people’s perceptions of smartphone-enabled self-testing and online care for sexually transmitted infections: qualitative interview study	2016	United Kingdom	STIs	Hypothetical	Mobile app	Partner notification
Optimizing Partner Notification Programs for Men Who Have Sex with Men: Factorial Survey Results from South China	2016	China	Syphilis	Hypothetical	Internet and mobile phone partner notification (e-mail, instant message, and short message service (SMS))	Partner notification/referral for treatment
Evaluation of Chlamydia Partner Notification Practices and Use of the “Let Them Know” Website by Family Planning Clinicians in Australia: Cross-Sectional Study	2016	Australia	Chlamydia	Real-life	Website (+ SMS, email, or letter)	Partner notification
Advancing Partner Notification Through Electronic Communication Technology: A Review of Acceptability and Utilization Research	2016	General	STIs	Real-life/hypothetical	Anonymous e-card, sender-identifiable email, SMS	Partner notification
Survey of partner notification practices for sexually transmissible infections in the United States	2016	United States of America	Chlamydia/ Gonorrhea/ HIV/ Syphilis	Real-life	Internet based PN system	Partner notification/ referral for treatment
Next-Generation Methods for HIV Partner Services: A Systematic Review	2015	General	HIV	Real-life	Anonymous or non-anonymous e-cards, sender-identifiable email, SMS/ email or SMS linked to networking/meeting websites	Partner notification/referral for testing/referral for treatment
Developing and testing accelerated partner therapy for partner notification for people with genital Chlamydia trachomatis diagnosed in primary care: a pilot randomised controlled trial	2015	United Kingdom	Chlamydia	Pilot	SMS for index case	SMS to index case with PIN code for partner

Use of new technologies to notify possible contagion of sexually-transmitted infections among men	2015	Spain	STIs/HIV	Real-life/hypothetical	SMS, email, webpage with pseudonym, mobile app to search for people	Partner notification
Potential Impact and Acceptability of Internet Partner Notification for Men Who Have Sex with Men and Transgender Women Recently Diagnosed with STD in Lima, Peru	2014	Peru	STIs/HIV	Hypothetical	Web based partner notification system	Partner notification
Acceptability and Intention to Seek Medical Care After Hypothetical Receipt of Patient-Delivered Partner Therapy or Electronic Partner Notification Postcards Among Men Who Have Sex With Men	2013	United States of America	STIs/HIV	Hypothetical	E-cards, patient-delivered partner therapy (PDPT)	Partner notification/referral for testing/ referral for treatment
Evaluation of inSPOTLA.org: An Internet Partner Notification Service	2012	United States of America	STIs/HIV	Real-life	E-cards	Partner notification

10. APPENDIX B. Determinants of PHPs' intention to use RDD-tools

Figure B1. Importance of variables in relation to PHPs' intention to use RDD-tool 1 (contact identification). Note that DCTS-tool = RDD-tool.



Interpretation of the figure:

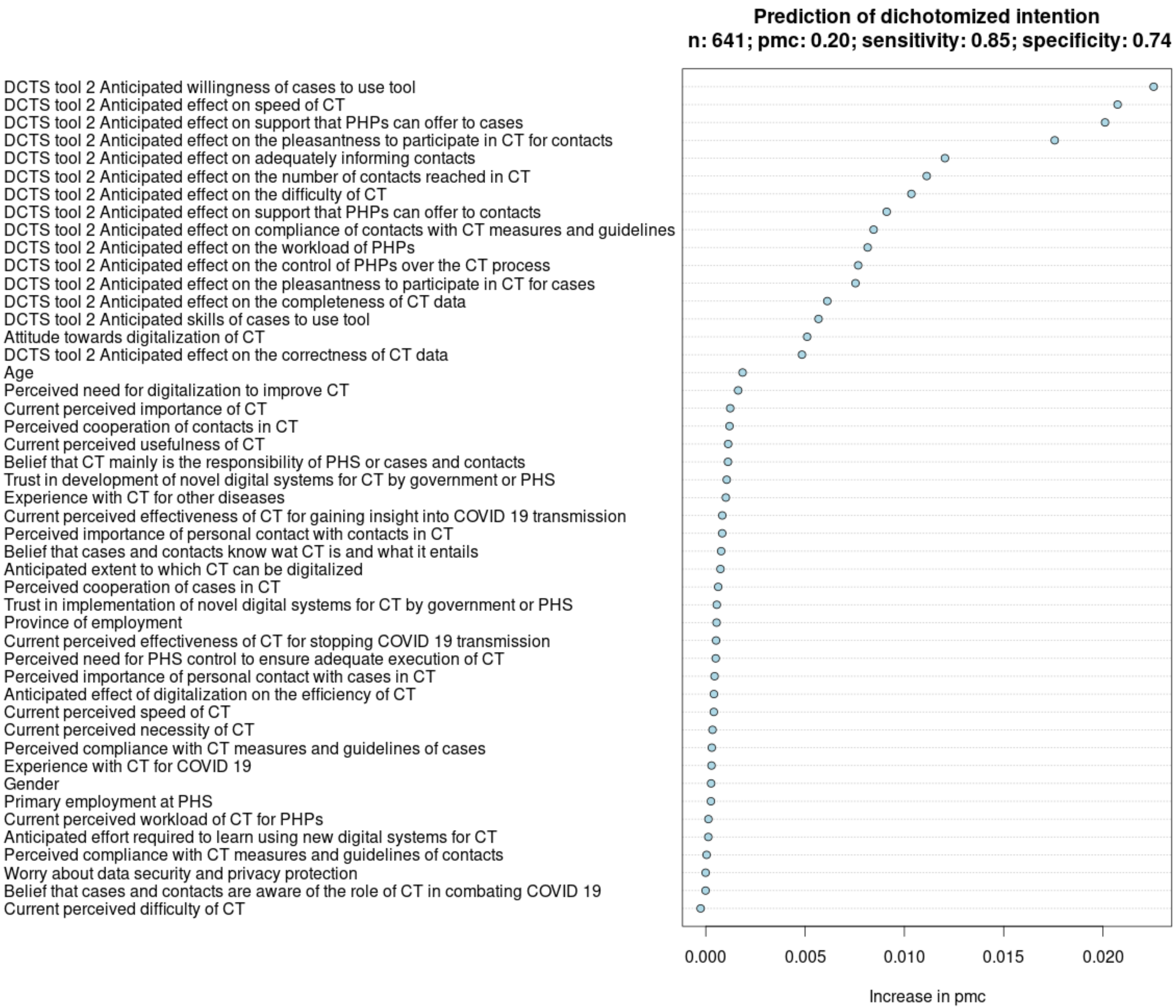
Pmc = model probability of incorrect prediction of intention

Sensitivity = model probability of correct prediction amongst individuals with a positive intention

Specificity = model probability of correct prediction amongst individuals with a negative intention

Increase in pmc = increase in model prediction error as a result of 'corrupting' a given variable. A larger increase in prediction error indicates greater importance of a variable to the accuracy of the model's predictions.

Figure B2. Importance of variables in relation to PHPs' intention to use RDD-tool 2 (contact notification). Note that DCTS-tool = RDD-tool.



Interpretation of the figure:

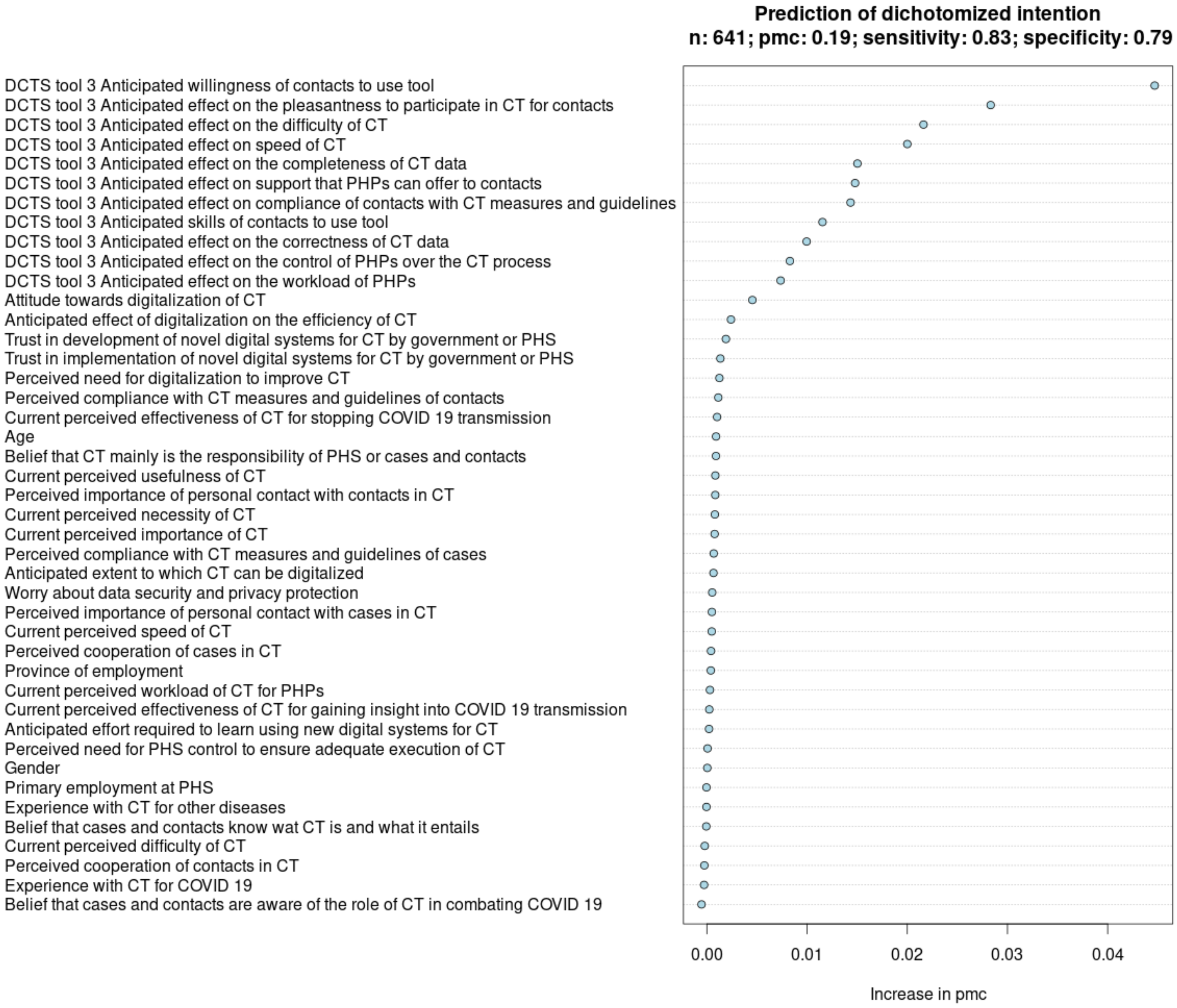
Pmc = model probability of incorrect prediction of intention

Sensitivity = model probability of correct prediction amongst individuals with a positive intention

Specificity = model probability of correct prediction amongst individuals with a negative intention

Increase in pmc = increase in model prediction error as a result of 'corrupting' a given variable. A larger increase in prediction error indicates greater importance of a variable to the accuracy of the model's predictions.

Figure B3. Importance of variables in relation to PHPs' intention to use RDD-tool 3 (contact monitoring). Note that DCTS-tool = RDD-tool.



Interpretation of the figure:

Pmc = model probability of incorrect prediction of intention

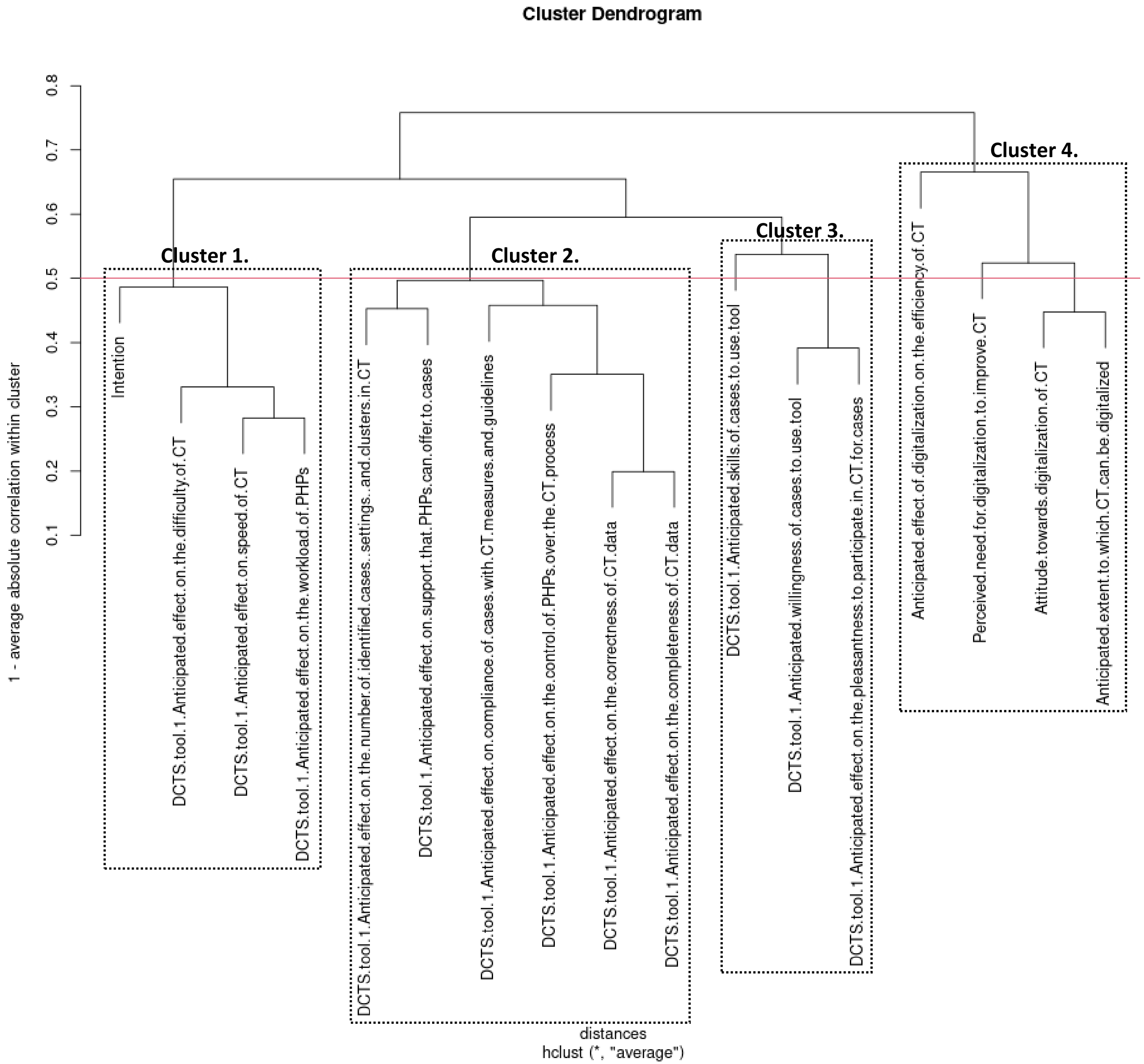
Sensitivity = model probability of correct prediction amongst individuals with a positive intention

Specificity = model probability of correct prediction amongst individuals with a negative intention

Increase in pmc = increase in model prediction error as a result of 'corrupting' a given variable. A larger increase in prediction error indicates greater importance of a variable to the accuracy of the model's predictions.

11. APPENDIX C. CLUSTER ANALYSES

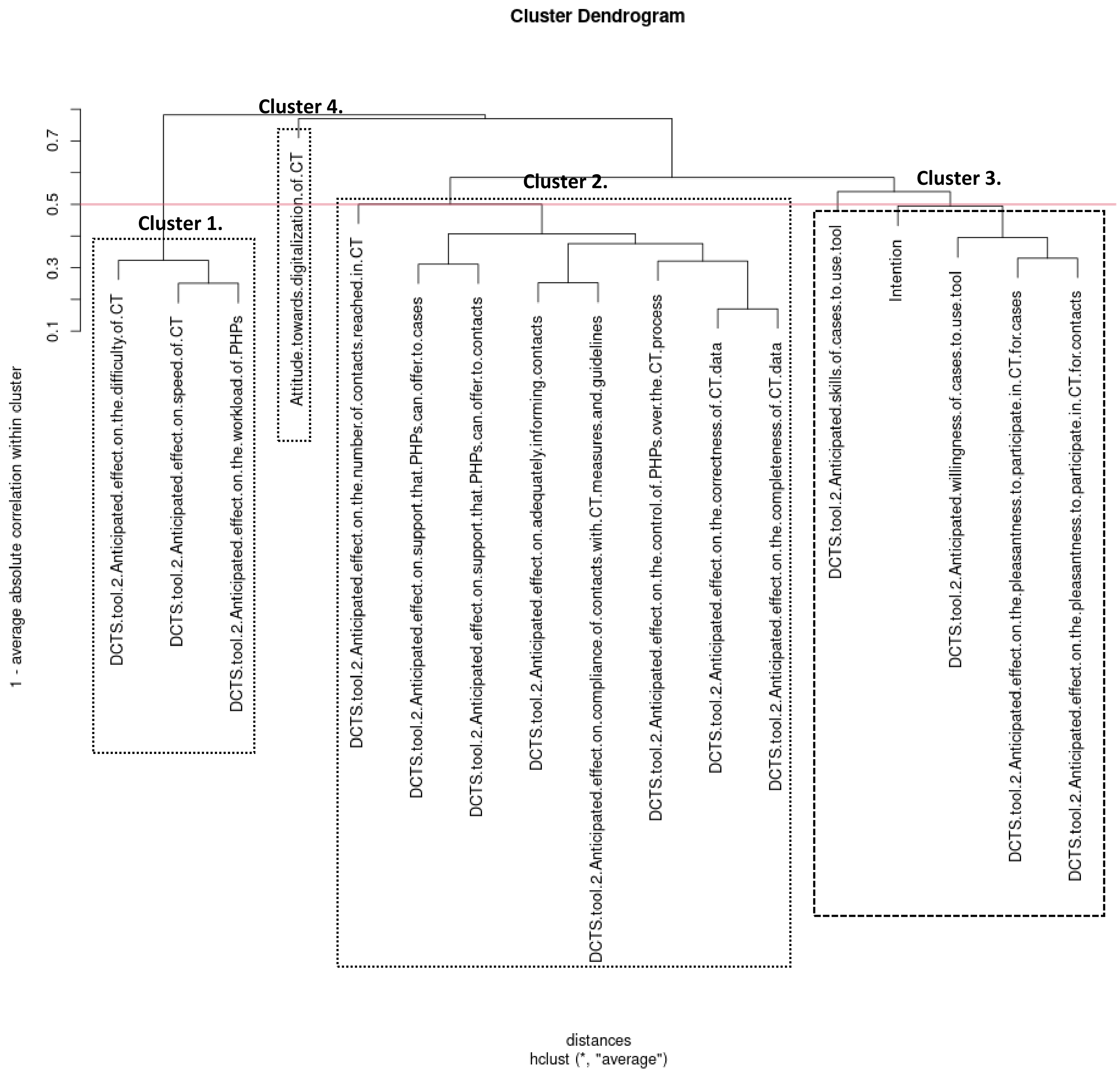
Figure C1. Cluster dendrogram of determinants – RDD-tool 1. Note that DCTS-tool = RDD-tool.



Interpretation of the figure:

The y-axis shows the 'distance' (i.e., 1 - the average absolute correlation) between individual and/or clusters of variables. The red line references a correlation of 0.5. Variables that are more closely linked together lower in the dendrogram are more closely/strongly correlated and vice versa. We distinguished and named 4 clusters: Cluster 1. 'Feasibility and efficiency of CT'; Cluster 2. 'Support for cases and contacts to adequately perform CT'; Cluster 3. 'Willingness, preferences and skills of cases and contacts'; and Cluster 4. 'Digitalization of CT'.

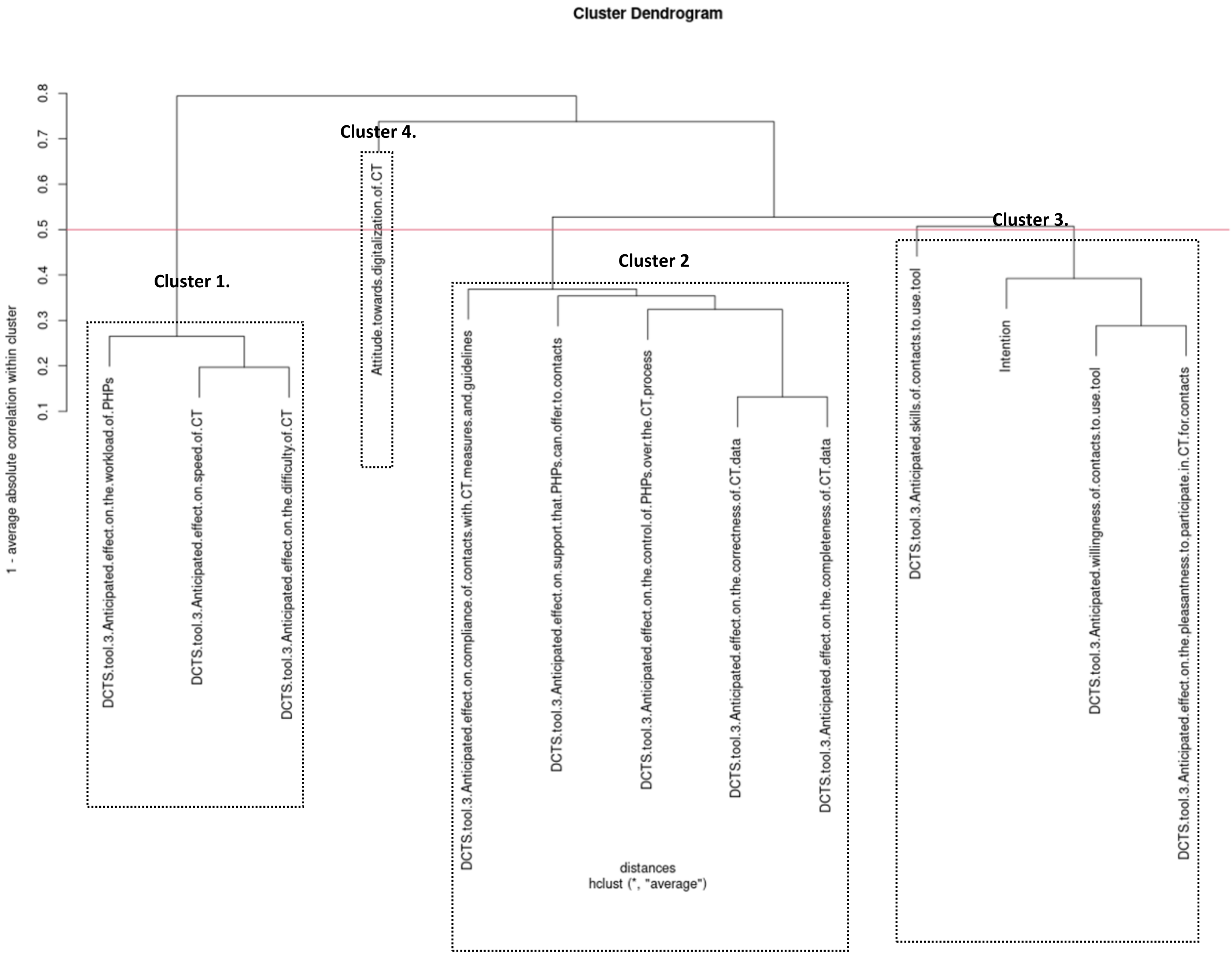
Figure C2. Cluster dendrogram of determinants, RDD-tool 2. Note that DCTS-tool = RDD-tool.



Interpretation of the figure:

The y-axis shows the 'distance' (i.e., 1 - the average absolute correlation) between individual and/or clusters of variables. The red line references a correlation of 0.5. Variables that are more closely linked together lower in the dendrogram are more closely/strongly correlated and vice versa. We distinguished and named 4 clusters: Cluster 1. 'Feasibility and efficiency of CT'; Cluster 2. 'Support for cases and contacts to adequately perform CT'; Cluster 3. 'Willingness, preferences and skills of cases and contacts'; and Cluster 4. 'Digitalization of CT'.

Figure C3. Cluster dendrogram of determinants, RDD-tool 3. Note that DCTS-tool = RDD-tool.



Interpretation of the figure:

The y-axis shows the 'distance' (i.e., 1 - the average absolute correlation) between individual and/or clusters of variables. The red line references a correlation of 0.5. Variables that are more closely linked together lower in the dendrogram are more closely/strongly correlated and vice versa. We distinguished and named 4 clusters: Cluster 1. 'Feasibility and efficiency of CT'; Cluster 2. 'Support for cases and contacts to adequately perform CT'; Cluster 3. 'Willingness, preferences and skills of cases and contacts'; and Cluster 4. 'Digitalization of CT'.