

**Supplementary Table 2. Summary of sampled apps' (n=24) data sharing practices**

| <b>App (Version no.)</b>             | <b>Third party (domain)</b> | <b>Third party owner</b> | <b>Category</b> | <b>Sub category</b>      | <b>Types of user data shared</b>   | <b>Description</b>   |
|--------------------------------------|-----------------------------|--------------------------|-----------------|--------------------------|--|--|
| Ada – Your Health Companion (2.10.0) | Ada Health                  | Ada Health               | Developer       | Digital health           | Browsing; Gender; Birthday; Symptoms; Email; Medical Conditions; Medications list; Personal conditions; Personal factors | Berlin-based, venture capital-backed, start-up offering the “AI-powered personal health guide”; they have masked their contact details using the Whois Privacy Service |
|                                      | Amazon Web Services, Inc.   | Amazon.com, Inc.         | Infrastructure  | Cloud services           | Browsing; Email; Medical conditions; Medications list; Personal conditions; Personal factors                             | Provides full cloud computing services from data storage, analytics, to backup and recovery  |
|                                      | Amazon Cloudfront           | Amazon.com, Inc.         | Infrastructure  | Content delivery network | Device name  | A content delivery network distributes services geographically so users experience high app performance  |
|                                      | Microsoft Azure Web Sites   | Microsoft Corporation    | Infrastructure  | Cloud services           | Android ID; +Birthday; Email;  | A platform for building, testing, deploying and  |

|  |                                     |                            |                |                    |  |   |
|--|-------------------------------------|----------------------------|----------------|--------------------|--|---|
|  |                                     |                            |                |                    | Feelings;<br>Gender;<br>Medical conditions;<br>Medications list; Name;<br>Personal conditions;<br>Personal factors | managing apps through Microsoft data centres  |
|  | <i>Hetzner Online GmbH</i>          | <i>Hetzner Online GmbH</i> | Infrastructure | Data storage       | Unknown  | Provides web hosting and storage in data centres located in Germany and Finland   |
|  | <i>MongoDB Cloud Services, Inc.</i> | <i>MongoDB, Inc.</i>       | Infrastructure | Database platform  | Unknown  | MongoDB provides a database software platform   |
|  | One Signal                          | One Signal                 | Engagement     | Push notifications | Device name  | A software delivery platform for push notifications; a free service that sells data to advertisers and research companies |
|  | Adjust                              | Adjust                     | Advertising    | Ad attribution     | Device name  | A service that “ties each user to the ads they interact with”   |
|  | Facebook Graph API                  | Facebook, Inc.             | Social media   |                    | Device name;<br>OS version;<br>Timezone;<br>Course grain location  | Used to get data in and out of the Facebook platform  |
|  | <i>Amplitude</i>                    | <i>Amplitude</i>           | Engagement     | Analytics          | Unknown  | Analyses how users navigate an app and  |

|                                       |  |                       |                  |                           |  |  |
|---------------------------------------|--|-----------------------|------------------|---------------------------|--|--|
|                                       |  |                       |                  |                           |  | which features they find most engaging   |
|                                       | <i>Sentry</i>  | <i>Sentry</i>         | Analytics        | Error reporting           | Unknown  | Finds and fixes software bugs, errors and crashes more efficiently   |
|                                       | <i>Zendesk</i>   | <i>Zendesk</i>        | Customer support |                           | Unknown  | Software for tracking, prioritizing and solving customer support tickets   |
|                                       | <i>Customer.io</i>   | <i>Customer.io</i>    | Engagement       | Triggered emails          | Unknown  | Sends triggered emails to users to improve user engagement   |
| CredibleMeds Mobile (2.9.6)           | Arizona Center for Education and Research on Therapeutics (AZCERT) | AZCERT                | Developer        | Clinical decision support | Browsing   | Organisation founded by Dr Ray Woosley focused on safe use of medications  |
|                                       | DigitalOcean   | DigitalOcean          | Infrastructure   | Cloud services            | Browsing   | A platform for building, testing, deploying and managing apps through DigitalOcean data centres  |
| Dental Prescriber (3.3)               |  |                       |                  |                           |  |  |
| Dosecast - Medication Reminder (5.12) | Montuno Software, LLC  | Montuno Software, LLC | Developer        | Medication adherence      | Timezone;<br>Doses;<br>Medications list;<br>Medications instructions;<br>Medications schedule;<br>Doctor name; | Montuno Software is a Boston-based mobile health software company focused on medication adherence; customers include health insurers, pharmaceutical |

|                                       |                         |                           |                        |                           |  |   |
|---------------------------------------|-------------------------|---------------------------|------------------------|---------------------------|--|---|
|                                       |                         |                           |                        |                           | Pharmacy name  | companies and health providers  |
|                                       | Apptimize               | Apptimize                 | Engagement             | A/B Testing               | Device name; OS version  | Allows developers to optimize, test and iterate their app design features   |
| DrugDoses (5.5)                       |                         |                           |                        |                           |  |   |
| Drugs.com Medication Guide (2.0.7.40) | Akamai Technologies     | Akamai Technologies, Inc. | Infrastructure         | Cloud services            | Browsing; Email; Gender; Medical conditions; Symptoms                    | Offers cloud computing services including data storage, security, analytics, and a content delivery network   |
|                                       | <i>Google Analytics</i> | Google, Inc.              | Analytics/ Advertising | Analytics                 | Unknown  | Analyzes user traffic and behaviour across platforms; it integrates with multiple advertising and other Google products   |
| Epocrates Plus (17.7.3)               | Epocrates Inc.          | AthenaHealth, Inc         | Developer              | Clinical decision support | Android ID; OS version; Device ID; Device name; Carrier; Connection type | Epocrates develops software to provide information and decision support tools for health professionals; it was acquired by AthenaHealth, a provider of cloud-based services for physicians, in 2013 |
|                                       | 24/7 Real Media         | AppNexus Inc.             | Advertising            | Ad network                | Browsing   | 24/7 Real Media sells web-based advertising, audience targeting and   |

|                  |                           |                  |                |                           |   |  |
|------------------|---------------------------|------------------|----------------|---------------------------|---|--|
|                  |                           |                  |                |                           |   | analytics; it was acquired by AppNexus, a multi-national ad network, in 2014, which in turn was acquired by AT&T, a telecommunications giant in 2018 |
|                  | Amazon Web Services, Inc. | Amazon.com, Inc. | Infrastructure | Cloud services            | Device name;<br>OS version;<br>Carrier;<br>Country;<br>Connection type;<br>Browsing | Provides full cloud computing services from data storage, analytics, to backup and recovery  |
| Lexicomp (4.0.1) | Lexi-Comp, Inc.           | Lexi-Comp, Inc.  | Developer      | Clinical decision support | Device name;<br>Email   | Lexi-Comp provides clinically-related mobile apps; it was acquired by the multinational publisher Wolters Kluwer in 2011                             |
|                  | Crashlytics               | Google Inc.      | Analytics      | Error reporting           | Android ID;<br>Device name  | Provides a software for crash and error reporting; it was acquired by Google and is offered as part of Firebase, Google's app development platform   |
|                  | AT&T                      | AT&T             | Infrastructure | Internet service provider | Device name;<br>Email   | AT&T is a multinational telecommunications and media conglomerate; for Lexi-   |

|                                      |                                     |                           |                        |                                 |  |  |
|--------------------------------------|-------------------------------------|---------------------------|------------------------|---------------------------------|--|--|
|                                      |                                     |                           |                        |                                 |  | Comp, it is an internet service provider   |
| Listmeds – Free (1.16.170531)        |                                     |                           |                        |                                 |  |  |
| Med Helper Pro Pill Reminder (2.7.6) | <i>Google Analytics</i>             | Google, Inc.              | Analytics/ Advertising | Analytics                       | Unknown  | Analyzes user traffic and behaviour across platforms; it integrates with multiple advertising and other Google products  |
| MediAdvisor (4.7.0)                  | MedAdvisor                          | MedAdvisor                | Developer              | Medication adherence            | Birthday; Browsing; Device name; Email; Medications list; Medications schedule; Password; Timezone | MedAdvisor is an Australian corporation that markets a medication adherence software platform; its revenue is derived from agreements with pharmacies and pharmaceutical companies |
|                                      | Bulletproof, Mission Critical Cloud | Bulletproof Group Limited | Infrastructure         | Managed cloud services          | Birthday; Browsing; Device name; Email; Medications list; Medications schedule; Password; Timezone | Bulletproof Group Limited is an Australian-owned, publicly listed cloud services provider; it offers managed cloud services through Amazon Web Services and Microsoft Azure        |
|                                      | Google.com                          | Google Inc.               | Infrastructure         | Cloud services and data storage | Browsing; Device name;   | Google also provides cloud services for  |

|                         |   |                           |                           |   |   |   |
|-------------------------|---|---------------------------|---------------------------|---|---|---|
|                         |   |                           |                           |   | Email;<br>Timezone                      | developers including<br>data storage  |
| MedicineWise<br>(3.0.3) | Urban Airship   | Urban Airship             | Engagement                | Push<br>notifications                                 | Device name                             | A service that analyses<br>users' patterns and<br>creates and delivers<br>personalised,<br>interactive notifications<br>to engage app users   |
|                         | Australian Academic<br>and Research<br>Network (AARNet) | 38 universities and CSIRO | Infrastructure            | Internet<br>service<br>provider;<br>cloud<br>services | Device name                             | AARNet is a not-for-<br>profit company that<br>operates Australia's<br>national research and<br>education network; it is<br>owned by 38 Australian<br>universities and the<br>Commonwealth<br>Scientific and Industrial<br>Research Organisation<br>(CSIRO) |
|                         | JanRain   | JanRain                   | Analytics/<br>Advertising | Identity<br>management                                | Email                                   | JanRain provides<br>customer identity and<br>access management,<br>which provides the<br>single sign-on feature,<br>security and analytics<br>around app registration<br>and log in processes   |
|                         | Facebook Graph API                                      | Facebook, Inc.            | Social media              |   | Device name;<br>OS version;<br>Timezone | Used to get data in and<br>out of the Facebook<br>platform  |
|                         | TUNE  | TUNE                      | Advertising               | Ad<br>attribution                                     | Connection<br>type; device              | TUNE provides app<br>store analytics, ad  |

|                     |   |                        |                |                           |                         |  |
|---------------------|---|------------------------|----------------|---------------------------|-------------------------|--|
|                     |   |                        |                |                           | name; OS version;       | attribution analytics, and in-app marketing  |
| MediTracker (1.7.1) | cdmNet                                  | Precedence Health Care | Developer      | Medication adherence      | Last name               | cdmNet is a cloud-based coordinated care platform that connects providers and patients; it is owned by Precedence Health Care, a privately held Australian company |
|                     | Crashlytics                             | Google Inc.            | Analytics      | Error reporting           | Android ID; Device name | Provides a software for crash and error reporting; it was acquired by Google and is offered as part of Firebase, Google's app development platform                 |
|                     | Rackspace Hosting Australia Limited PTY | Rackspace, Inc.        | Infrastructure | Managed cloud services    | Last name; Name         | Provides services to migrate and operate cloud-based apps within third party cloud services such as Amazon Web Services, Microsoft Azure, or Google Cloud          |
| Medscape (4.3)      | Medscape                                | WebMD, LLC             | Developer      | Clinical decision support | Browsing; Email         | Medscape, owned by WebMD is an online portal for health information targeted at physicians and health professionals  |
|                     | WebMD, LLC                              | WebMD, LLC             | Owner          | Clinical decision support | Browsing; Device Name   | WebMD provides medical information to consumers and health   |



|  |                     |                           |                |                          |   |  |
|--|---------------------|---------------------------|----------------|--------------------------|---|--|
|  |                     |                           |                |                          |   | professionals through online portals and mobile apps; it was recently acquired by Internet Brands  |
|  | Cloudflare          | Cloudflare                | Infrastructure | Content delivery network | Browsing;<br>Email  | Speeds up and protects websites and APIs; offers analytics   |
|  | Adobe Systems       | Adobe Systems             | Infrastructure | Cloud services           | Browsing;<br>Device name;<br>OS version                           | Adobe Systems offers a Cloud Platform that allows developers to centralise their users' data, analyse it and to onboard content in response        |
|  | Akamai Technologies | Akamai Technologies, Inc. | Infrastructure | Cloud services           | Device name;<br>OS version  | Offers cloud computing services including data storage, security, analytics, and a content delivery network  |
|  | Crashlytics         | Google Inc.               | Analytics      | Error reporting          | Android ID;<br>Device name  | Provides a software for crash and error reporting; it was acquired by Google and is offered as part of Firebase, Google's app development platform |
|  | Facebook Graph API  | Facebook, Inc.            | Social media   |                          | Course grain location;<br>Device name;<br>OS version;<br>Timezone | Used to get data in and out of the Facebook platform   |

|  |                               |                           |                        |                      |  |   |
|--|-------------------------------|---------------------------|------------------------|----------------------|--|---|
|  | Braze (formerly AppBoy, Inc.) | Braze, Inc.               | Engagement             | Push notifications   | Course grain location; Device name; Timezone   | Braze is a mobile marketing company that allows developers to build customer profiles to segment, personalise and optimize messaging  |
| Medsmart Meds & Pill Reminder App (1.32) | Talking Medicines             | Talking Medicines Limited | Developer              | Medication adherence | Birthday, Email; Feelings; Gender; Last name; Medical conditions; Medications list; Name | This company uses the app to collect “real world data” about medicines use from patients and sells this data and analyses to “healthcare stakeholders” including pharmaceutical companies |
|  | Mixpanel                      | Mixpanel                  | Engagement             | Analytics            | Carrier; Connection type; Device name; Medications list; OS version                      | Offers a suite of analytics services including measuring users’ actions, retention tools, funnel analysis, push notifications, mobile A/B testing and “people analytics”                  |
|  | <i>Google Analytics</i>       | Google, Inc.              | Analytics/ Advertising | Analytics            | Unknown  | Analyzes user traffic and behaviour across platforms; it integrates with multiple advertising and other Google products   |
|  | Microsoft Azure Web Sites     | Microsoft Corporation     | Infrastructure         | Cloud services       | Birthday, Email;   | A platform for building, testing, deploying and   |

|                                       |                  |                |                |                           |  |  |
|---------------------------------------|------------------|----------------|----------------|---------------------------|--|--|
|                                       |                  |                |                |                           | Feelings;<br>Gender; Last name;<br>Medical conditions;<br>Medications list; Name | managing apps through Microsoft data centres   |
| MIMS For Android (2.0.10)             | MIMS For Android | MIMS Australia | Developer      | Clinical decision support | Device name;<br>Email;<br>Password   | An Australian-based publisher of print and online medicines information for health professionals   |
|                                       | TPG Internet     | TPG Internet   | Infrastructure | Cloud services            | Device name;<br>Email;<br>Password   | TPG Internet is an Australian-based telecommunications company that offers cloud services  |
| My PillBox(Meds&Pill Reminder) (1.42) |                  |                |                |                           |  |  |
| MyMeds (5.3.6)                        | MyMeds, Inc.     | MyMeds, Inc.   | Developer      | Medication adherence      | Email;<br>Medication instructions;<br>Medications list                           | MyMeds is a software company focused on medication adherence and clinical coordination   |
|                                       | Crashlytics      | Google Inc.    | Analytics      | Error reporting           | Android ID;<br>Device name   | Provides a software for crash and error reporting; it was acquired by Google and is offered as part of Firebase, Google's app development platform |

|                                   |                           |                       |                |                          |  |  |
|-----------------------------------|---------------------------|-----------------------|----------------|--------------------------|--|--|
|                                   | Tier 3                    | CenturyLink           | Infrastructure | Managed cloud services   | Email; Medication instructions; Medications list | Tier 3 is a cloud services company owned by Louisiana-based CenturyLink, a telecommunications corporation; they offer a cloud application manager service                    |
| myPharmacyLink (1.3.2)            | Cloudflare                | Cloudflare            | Infrastructure | Content delivery network | Device ID; Last name                             | Speeds up and protects websites and APIs; offers analytics   |
|                                   | Microsoft Azure Web Sites | Microsoft Corporation | Infrastructure | Cloud services           | Browsing; Device name; OS version                | A platform for building, testing, deploying and managing apps through Microsoft data centres   |
| Nurse's Drug Handbook (2.3.1.380) | Atmosphere Apps           | USBMIS                | Developer      | App development          | Android ID                                       | Freelance app development company specialising in publishing print medical references on a mobile platform; they offer full app design, optimisation, and analytics services |
|                                   | USBMIS                    | USBMIS                | Owner          | App development          | Android ID; Browsing                             | USBMIS is the parent company of Atmosphere Apps  |
|                                   | Linode                    | Linode                | Infrastructure | Cloud services           | Android ID                                       | Linode is a Philadelphia based cloud services provider   |
|                                   | Crashlytics               | Google Inc.           | Analytics      | Error reporting          | Android ID; Device name                          | Provides a software for crash and error reporting; it was  |

|  |                                     |                  |                           |                |   |  |
|--|-------------------------------------|------------------|---------------------------|----------------|---|--|
|  |                                     |                  |                           |                |   | acquired by Google and is offered as part of Firebase, Google's app development platform   |
|  | Flurry                              | Yahoo! Inc.      | Analytics/<br>Advertising | Analytics      | Android ID;<br>Device name;<br>OS version | Flurry is a mobile analytics, monetization and advertising company that was acquired by Yahoo! In 2014; Yahoo! was in turn, acquired by Verizon Communications, a telecommunications giant |
|  | Amazon Web Services, Inc.           | Amazon.com, Inc. | Infrastructure            | Cloud services | Browsing                                  | Provides full cloud computing services from data storage, analytics, to backup and recovery  |
| Nurse's Pocket Drug Guide 2015 (8.0.250) | <i>Google Analytics</i>             | Google, Inc.     | Analytics/<br>Advertising | Analytics      | Unknown                                   | Analyzes user traffic and behaviour across platforms; it integrates with multiple advertising and other Google products  |
|  | <i>Audience Network by Facebook</i> | Facebook, Inc.   | Advertising               | Ad network     | Unknown                                   | Allows brands to advertise outside of Facebook using the same targeting data they use on Facebook  |
|  | <i>AdMob by Google</i>              | Google, Inc.     | Advertising               | Ad network     | Unknown                                   | A mobile advertising network that helps  |

|                                     |                              |   |                        |                  |  |   |
|-------------------------------------|------------------------------|---|------------------------|------------------|--|---|
|                                     |                              |   |                        |                  |  | developers monetize and promote their apps with ads; it was acquired by Google in 2009                                  |
| Pedi Safe Medications (3.4)         |                              |   |                        |                  |  |   |
| Pill Identifier and Drug list (3.5) | Mobixed, LLC                 | B3Net   | Developer              | App development  | Browsing; Medical conditions; Medications list | Mobixed is an app development company that was spun off from B3Net, a California-based web development company          |
|                                     | Google Analytics             | Google, Inc.  | Analytics/ Advertising | Analytics        | Browsing; Device name; OS version              | Analyzes user traffic and behaviour across platforms; it integrates with multiple advertising and other Google products |
|                                     | National Library of Medicine | United States Department of Health and Human Services | Research               | Drug information | Browsing                                       | The Medical Ontology Research project is conducting basic research on biomedical terminologies (e.g. drug names)        |
|                                     | GoDaddy.com, LLC             | GoDaddy.com, LLC                                      | Infrastructure         | Cloud services   | Browsing; Medical conditions; Medications list | Provides domain registration and web hosting  |

|                               |               |                |             |                           |  |  |
|-------------------------------|---------------|----------------|-------------|---------------------------|--|--|
| UpToDate for Android (2.28.1) | UpToDate Inc. | Wolters Kluwer | Developer   | Clinical decision support | Android ID; Connection; type Device ID; OS version | UpToDate is a peer-reviewed clinical decision support resource; it was acquired by the multinational publishing company Wolters Kluwer             |
|                               | AppsFlyer     | AppsFlyer      | Advertising | Ad attribution            | Android ID; Device ID; Device name                 | Representing advertisers, AppsFlyer provide mobile attribution and marketing analytics   |
|                               | Crashlytics   | Google Inc.    | Analytics   | Error reporting           | Android ID; Device name; OS version                | Provides a software for crash and error reporting; it was acquired by Google and is offered as part of Firebase, Google's app development platform |

*Italics: Third parties identified by developer self-report*