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When, how, and how long do adults in Germany self-reportedly wash their hands? Compliance indices based on handwashing frequency, technique, and duration from a cross-sectional representative survey

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ABSTRACT

Background: Hand hygiene is an efficacious behaviour to prevent community-associated infections. Estimates of the proportion of populations who wash their hands have indicated limited compliance. While biases of self-report items for hand hygiene, such as the tendency to overestimate one's behaviour, represent a limitation, direct survey questions remain important. This study aims to compare indices of handwashing compliance based on single vs. combined handwashing attributes, i.e., its frequency, technique, and duration.

Methods: Data of a representative survey on hygiene and infection control by the German Federal Centre for Health Education were analysed. In a cross-sectional, computer-assisted telephone interview design, the resident population in Germany aged 16-85 years was surveyed in 2012. For handwashing, duration, frequency in different situations, and technique (use of soap, washing interdigital spaces, and drying hands) were selfreported. Self-reports were rated as (non-)compliant based on national recommendations and combined into single- and multi-attribute indices. Use of hand disinfectants, recall of handwashing instruction plates in public restrooms, and socio-demographics were also assessed. In total, N = 4483 persons participated (response rate: 49.7%). Data were weighted to compensate for sampling bias and analysed by cross-tabulation and multiple logistic regression. Primarily due to missing data, the analysis was confined to N = 4093 respondents (i.e., 91%). Results: Among women, the proportion of those who reported to wash hands "almost always" in at least seven of nine situations was 30.8% (men: 20.3%). In contrast, 51% of men reported always using soap, drying hands, and washing interdigital spaces (women: 43.5%; p < 0.001). Compliance based on indices that included "frequency" was higher in women by 5.2% for "frequency + technique" (17.6% vs. 12.4%), and 2.5% for "frequency + duration" (13.1% vs. 10.6%) and "frequency + duration + technique" (8.8% vs. 6.3%; p < 0.02). Sociodemographic differences were most consistent regarding higher compliance among healthcare workers. Finally, especially men recalling handwashing instruction plates in public restrooms had higher compliance than those with no recall, namely, for "frequency + technique" (15.4% vs. 10.6%; OR: 1.9), all three attributes (7.6% vs. 5.3%; OR = 1.7), and "technique" (56.9% vs. 47.7%; OR = 1.6). The highest odds ratio was noted for disinfectant use among men (OR = 2.5; 12.2% vs. 4.9%).

Discussion: While being representative for Germany, limitations include the survey's cross-sectionality, response rate, and the study representing the situation in 2012. Nonetheless, indices based on combined attributes allow better comparison to scarce compliance estimates for Germany based on observation. Socio-demographic differences add to existing evidence, e.g., higher compliance by healthcare workers. Finally, although reverse causation is possible, it is notable that although handwashing instruction plates in public restrooms focus on duration and technique, women recalling them reported higher frequency, and men more often report hand disinfectant use, suggesting possible carry-over effects.

Conclusion: Self-reported handwashing compliance assessment may be improved by partitioning the behavioural domain into different attributes and using indices based on combinations of these.

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1. Introduction

Hand hygiene compliance in general populations has received new prominence in the context of the current novel coronavirus pandemic (Lynch et al., 2020). It represents an efficacious public health behaviour in the prevention of community-associated infections, e.g., infections of the respiratory tract (Aiello et al., 2008; Rabie and Curtis, 2006), gastrointestinal tract (e.g., diarrhoea; Ejemot-Nwadiaro et al., 2015; Wolf et al., 2018), and skin and soft tissue (Gupta et al., 2015). In addition, estimates of the proportion of the global population who wash their hands with soap when indicated have pointed to limited compliance, e.g., handwashing after potential faecal contact in the range of 19% and 26% (Freeman et al., 2014; Wolf et al., 2019a). While these estimates were deliberately based on observed behaviour only, mainly to avoid biases of self-report measures, such as the well-documented tendency to overestimate one's behaviour (Ram, 2013), self-reports of handwashing practices remain important for several reasons. First, as has been stated for healthcare professionals, but holds for laypeople as well, "... if people believe that their hand hygiene is much better than it is, they are likely to be oblivious to current campaigns that aim to increase hand hygiene behaviour ..." (Jenner et al., 2006)^{p. 421}. Second, and related to this point, behaviour change techniques, such as "incompatible beliefs", i.e., drawing attention to discrepancies between one's own behaviour and respective self-images (Michie et al., 2013), can use subjective compliance estimates as a reference of comparison when providing "feedback on behaviour" (as another, cognate behaviour change technique). Doing so may induce cognitive dissonance, i.e., contradictory beliefs of one's compliance, which may serve as a motivation to improve one's compliance. Third, objective measures of hand hygiene, such as direct observation or automated methods (e.g., video-monitored direct observation systems or electronic dispenser counters; Ward et al., 2014) often are either costly in terms of time and resources required or have specific limitations of their own regarding reliability and validity (Diefenbacher et al., 2016; Ram, 2013). For instance, direct observations of handwashing may be limited by high demands regarding required time and effort, issues of data privacy, heterogeneous observer training and methodology, and the Hawthorne effect.

One recent approach to mitigate over-reporting in hand hygiene assessment has been to ask respondents to reconstruct entire days or processes encompassing or leading to the behaviour instead of directly asking about the behaviour. Examples are the day reconstruction method (DRM) (Kahneman et al., 2004), which has been applied to hand hygiene of healthcare workers (Sassenrath et al., 2016), and the script-based covert recall method (Bradburn, 2000), which has been applied to population handwashing behaviour (Contzen et al., 2015). These methods try to reduce recall biases and social desirability by placing the target behaviour into context and assessing it indirectly. However, while representing promising advances in terms of increased self-report validity, hand hygiene studies using these methods to date have focused on one parameter of this behaviour, namely, the frequency with which it is performed given specific indications (Contzen et al., 2015; Sassenrath et al., 2016). This limitation is likely at least partly due to extra survey time needed for reconstructions and diaries. In any case, both the duration and technique of handwashing have been neglected. These features are relevant for effective hand hygiene over and beyond the frequency with which handwashing behaviour is performed. This notion also holds for duration (Jensen et al., 2015; Mumma et al., 2019), washing interdigital spaces (Chamberlain et al., 1997; Mumma et al., 2019), and drying hands (Gammon and Hunt, 2019; Jensen et al., 2015).

The present paper pursues two interrelated objectives. First, it aims to tackle the problem of over-reporting in general population surveys on hand hygiene as a behavioural domain within the "direct questions" paradigm. As Fig. 1 visualizes, for present purposes, this domain is partitioned into two behaviours: handwashing and hand disinfection. Both of these behaviours can be described by at least three attributes:

frequency, technique, and duration. Duration is defined as the usual period of time taken to wash or rub one's hands. In contrast, "facets" can be distinguished for both frequency and technique. Regarding frequency, it is defined here as the different situations in which the behaviour is recommended, e.g., "after using the toilet". Similar to professional hand hygiene (e.g. WHO, 2009), such situations are termed "indications". Regarding technique, using water, using soap, washing interdigital spaces, and drying one's hands are relevant facets. On this basis, the present study will compare different indices of self-reported handwashing compliance based on single and combined attributes. Compliance will be defined as correspondence with recommendations made available by the German Federal Centre for Health Education (Bundeszentrale für gesundheitliche Aufklärung) (BZgA, 2020). Thus, the study intends to contribute to the development of direct self-report measures of handwashing, and simultaneously overcome the previous focus on behavioural frequency.

Second, this study aims to describe associations of these indices of handwashing compliance with socio-demographics and self-reported recall of handwashing instruction plates in public restrooms. Such reminders have been used in Germany since the 2009 H1N1 pandemic (Meilicke et al., 2013; for details: https://www.infektionsschutz.de /mediathek/infografiken.html). Plates include information on handwashing technique and duration. In the present context, associations of recalling these plates with different self-reported hand hygiene indices may contribute to the understanding of the latter.

Moreover, the term "compliance" is used throughout this paper to denote the extent to which behaviour corresponds with recommendations regardless of whether those behaving agree with these recommendations (which would imply "adherence"). This is exclusively because the available data allows the assessment only of correspondence not agreement and represents no counter-argument to the "adherence" concept and its benefits (WHO, 2003).

In sum, it is worthwhile to further understand overestimation effects in hand hygiene self-reports and to develop alternative self-report measures by improving survey items and indices. Such improvement may merge the survey method's practicality and efficiency with increased validity.

2. Materials and methods

2.1. Study design, setting, and participants

We used data of the BZgA's first representative survey on hygiene and infection control conducted by the Forsa Institute for Social Research and Statistical Analysis from June-August 2012 as a crosssectional, computer-assisted telephone interview survey of the adult population in Germany aged 16-85 years (BZgA, 2013). It used a dual-frame multi-stage random sampling design based on the then current selection framework by the Working Group of German Market and Social Research Institutes (ADM Arbeitskreis Deutscher Markt- und Sozialforschungsinstitute, 1999) to include individuals reachable by cellular mobile telephone only. Within households reached via fixed-line, the person included was selected by the last birthday method. The sample was augmented to include a sub-sample of women pregnant at the time of the survey. This group is not addressed in the present analysis due to its aim to provide estimates for the general population, and both women and men; thus, this feature is taken into account in data weighting only (see below). The realized net sample consisted of N = 4483 respondents, including N = 3730 from the fixed-line and N = 753from the mobile sampling frame. The survey response rates were 53.2% for the former and 38.7% for the latter, resulting in an overall rate of 49.7%. In statistical analyses, data were weighted to compensate for sampling biases inherent both in the differential selection probabilities for the two sampling frames and the oversampling of pregnant women. The data are publicly available online at the Data Archive for the Social Sciences of the GESIS Leibniz Institute for the Social Sciences (BZgA,

2015).

2.2. Measures: survey items and compliance indices

In the following sections, authors' translations of the original German survey items into English are provided. The original items are available from the corresponding author and in BZgA (2015). For all items, the answer categories "I don't know" and "Not specified" were not presented in the interview but coded either if the respondent either gave a respective answer by him- or herself, or responded in a way that after could, after clarification, be fitted validly into one of the categories by the interviewer.

2.2.1. Handwashing compliance

The attribute *frequency* was operationalized for nine indications (facets) using the following item: *How often do you wash your hands in each of the following situations,* i.e., *never, seldom, mostly, or almost always*? Indications were "before eating", "after touching animals", "after shaking hands", "before preparing food", "when coming home from outside", "after using the toilet", "after blowing one's nose or coughing

in one's hand", "after being with someone who had the flu, a gastrointestinal disease, or a similarly contagious disease", and "before visiting a person who is weak because of ill-health". In the first step of the indexing process, each of the nine facets was dichotomized so that "almost always" was coded as "compliant". Then, the frequency of the code "compliant" was summed across the nine new variables, yielding a new variable for the number of indications with compliant handwashing frequency (range: 0-9). Values of this variable >0 were trichotomized into approximately equal groups, yielding groups with 1-3, 4-6, or 7-9indications with compliant handwashing frequency. Following a practice by Wolf et al. (2019b), these choices were made subjectively "... as a simplified approach and in order to get a good distribution of scores" (Wolf et al., 2019b, p. 272).

For technique, three facets were distinguished. First, use of soap or wash lotion was assessed by the following item: If possible, do you always use soap or wash lotion for handwashing, or do you usually wash your hands just with clear water without soap? Possible answers included "If possible always with soap or wash lotion", "Mostly only with clear water", or "Differently every time". The inclusion of interdigital spaces in handwashing was operationalized as follows: Do you wash your hands between



Fig. 1. Terminology employed for structuring and operationalizing general population hand hygiene as a behavioural domain.[§] *Notes:* [§]Hand disinfection is used to denote hand rubbing in terms of using an alcohol-containing preparation designed for application to the hands. In the present survey, facets are represented by individual items. Attributes and facets for which data were unavailable in this study are indicated in italics.

the fingers? "almost always", "mostly", "seldom", or "never". For hand drying, the item *Do you dry your hands carefully after handwashing*? was used with the same answer categories as that for interdigital spaces. The first indexing step was to dichotomize these variables by coding "If possible always with soap or wash lotion" and "almost always" as compliant. Then, the number of times the code "compliant" occurred was summed across the three new variables. This yielded a new variable (range: 0–3) representing the number of technical facets self-reportedly complied with.

The attribute *duration* was operationalized by the item *According to your estimation, how long does it usually take to wash your hands:* "Less than 10 s", "10 s to under 20 s", or "20 s or more"? According to recommendations, 20 s or more was coded as "compliant".

For indices combining either pairs of or all three attributes (frequency, technique, and duration), the number of "compliant"-ratings was summed across each pair, resulting in variables with three values (0–2), and across all three attributes, resulting in a variable with four values (0–3). For some analyses, these variables were re-coded into high compliance (highest value) and groups of lower compliance.

2.2.2. Hand disinfection behaviour

The item for use of hand disinfectants (not designated as "compliance" in this study because no recommendations exist for the public in Germany) read as follows: *Do you use disinfectants to sanitize your hands in your daily routine*? Do you use it "regularly", "only in specific situations", or "never"? Thus, for hand disinfection, only overall frequency is examined.

2.2.3. Self-reported recall of handwashing instruction plates in public restrooms

This item read as follows: In some public toilets, there is an instruction plate on the top of the mirror above the sink explaining step by step what to pay attention to when washing one's hands. Have you seen such an instruction plate before or have you not seen such a plate before? As answer categories, "seen before" and "never seen such a plate" were provided.

2.2.4. Socio-demographics

Sex and age were assessed by single items, the latter being inferred by the difference between the survey date and the birthday reported by respondent. Items assessing educational background (formal school education), current employment status, work in healthcare, migration background ("with migration background" was coded if the country of birth of both the respondent and his parents was not Germany and/or their citizenship was not German), and number of children living in the respondent's household can be found in Table S1 (available in the supplementary material). Indexing algorithms followed sociodemographic standards by the German Federal Statistical Office (Hoffmeyer-Zlotnik et al., 2010) and are available upon request from the corresponding author.

2.3. Statistical analysis

Analyses were conducted separately for women and men due to gender differences in handwashing frequency (women > men) (White et al., 2020). As noted before, data were weighted to compensate for sampling biases (fixed-line vs. cellular mobile, and oversampling of pregnant women) (BZgA, 2013). In addition to cross-tabulations, in which 95% confidence intervals were calculated with OpenEpi v3.01 (Dean and Soe, 2013), multiple logistic regression analyses were conducted with IBM® SPSS® Statistics v26. All tests were two-sided. Statistical significance was defined as a *p*-value less than 0.05, and *p*-values greater than 0.001 are reported with exact figures to three decimal places.

3. Results

3.1. Sample description

N = 2 respondents (0.04%) who indicated never washing their hands in daily practice and N = 39 (0.9%) with a missing value in this variable were excluded. Additionally, N = 325 (7.2%) with missing data in the variables sex, age or handwashing attributes (frequency, technique, and duration) were excluded. Thus, valid data were available from 4117 participants. After weighting the data as described above (see *Study design and sample*-section), the analytical sample was N = 4093.

Stratified for women and men, Table 1 shows the socio-demographic attributes of these respondents. Regarding age, women were on average 1.7 years older than men. Among both sexes, approximately 40% reported secondary general school as their highest degree. While about half of the women were currently working, this was around two-thirds for men. In contrast, the proportion of respondents with any type of professional activity in healthcare was higher in women (14.2%) than in men (5.1%; when related to those in employment, training, education or maternal or parental leave, these rates - not shown here - were 23.7% and 7.4%, respectively). Rates of respondents with any migration background (see Table S1 for details) were generally similar among women and men; this cross-tabulation was the only one with an insignificant Chi²-statistic (p = 0.243; all others at least p \leq 0.025). Approximately 28.6% of the women lived in the same household with at least one child under 16 years, while 21.7% among men did. Finally, 40.3% of the women reported to have seen a handwashing instruction plate in public restrooms at least once (men: 35.5%).

Table 1	
Sample description [§] .	

	Women			Men		
	N	%		N	%	
TOTAL	2111	51.6 ^{\$}		1982	48.4 ^{\$}	
Age						
16-29 years	404	19.1		421	21.3	
30-44 years	509	24.1		505	25.5	
45–59 years	578	27.4		564	28.4	
60-85 years	619	29.3		492	24.8	
Mean (SD)			48.2			46.5
			(17.9)			(17.3)
Educational backgroun	nd					
low (secondary general school)	848	40.2		831	42.2	
medium	724	34.5		509	25.8	
(intermediate school)						
high (upper	527	25.1		629	32.0	
secondary school)						
Currently working						
Yes	1076	52.4		1264	65.0	
No	978	47.6		680	35.0	
Healthcare worker						
Yes	300	14.2		100	5.1	
No	1811	85.8		1882	94.9	
Migration background						
Yes	438	20.8		383	19.3	
No	1669	79.2		1599	80.7	
Children in the househ	old					
Yes	601	28.6		428	21.7	
No	1503	71.4		1543	78.3	
Recalling having seen	handwas	shing inst	ruction plat	es in pu	blic restro	ooms
At least once	848	40.3	-	700	35.5	
No	1255	59.7		1274	64.5	

Notes: [§]Differences to sample description in BZgA (2013) due to differences in exclusion criteria applied (for details, see *3.1. Sample description*) [§]Row-% (all other rates: column-%, whereby all sub-samples not adding up to total are due to missing values).

3.2. Distributions of self-reported handwashing behaviour as defined by single and combined attributes

Related to when, how, and how long German adults self-reportedly wash their hands, Table 2 shows the distributions of handwashing frequency and technique facets, and use of hand disinfectants, while Table 3 shows the distributions of the different indices defined by single or combined attributes, i.e., frequency, technique, and duration. As Table 2 shows, lower rates of reporting to wash hands "almost always" among men pertained to all nine indications, albeit on very different levels, i.e., from 98.1% for "After toilet" among women to 6% for "After handshake" among men. Regarding technical facets, higher rates pertained to men, and compliance was highest for using soap (women: 85.8%, men: 88.1%), and lowest for interdigital spaces (62.7% and 68.1%). As Table 3 shows, 30.8% among women and 20.3% among men reported washing their hands in seven or more of the indications. In contrast, for handwashing technique and duration, higher compliance rates were reported by men: 51% reported to always use soap, dry their hands, and wash interdigital spaces (women: 43.5). Regarding duration, i.e. washing one's hands 20 s or more, the difference was less pronounced.

As Table 3 further indicates, compliance rates in all indices based on combined attributes, including the frequency attribute, were increased in women compared with men. For both women and men, the numerically highest rate was found for the combination of technique and duration followed by frequency and technique and the frequency and duration. Expectably, compliance based on the combination of all three attributes was lowest both in women and men. Finally, more women than men used hand disinfectants (Table 2). To reiterate, this does not denote compliance due to non-existent recommendations.

3.3. Associations of handwashing compliance indices based on single vs. combined attributes, and use of hand disinfectants, with sociodemographics and self-reported recall of handwashing instruction plates in public restrooms

Associations of handwashing compliance indices and disinfectant use with socio-demographics and recall of handwashing instruction plates are documented as cross-tabulations in Table 4 and multiple logistic regressions in Table 5. Among women, differences in handwashing compliance across age groups were minor and generally statistically insignificant. The two oldest groups among men tended to report higher handwashing compliance than the youngest group. This especially pertained to frequency and duration as single attributes and the combination of technique and duration (p's for all Chi^2 -statistics ≤ 0.001 [not shown], and odds ratios (ORs) ranging from 1.4 to 2.4; see Table 5). Regarding the combination of frequency and technique, and all attributes, those 30-44 years of age reported lower compliance than the youngest men. In contrast, age differences regarding use of hand disinfectants were significant only in women ($Chi^2 = 63.2$): all older age groups reported less use than women aged 16 to 29 (see Table 5). This finding corresponded to rates of regular use of 22.3% in younger women vs. lower rates in older groups (see Table 4).

Across educational groups, significant differences indicated lower handwashing compliance in the highest echelon compared with those with intermediate or secondary general school as their highest degree. This pattern pertained to women and men, but was more pronounced in men. Notably, only the combination of all three attributes showed no significant differences between low vs. medium or high educational level (see Table 5). Regarding regular use of hand disinfectants, among women, those with intermediate schooling reported the highest use with only the contrast to higher education being significant. The pattern was similar for men albeit on a lower level of compliance (10.4% vs. 5.4% and 7.8%); however, both contrasts were significant (p = 0.042 in both cases).

Regarding working status, most consistent associations pertained to

Table 2

Distributions of original survey items on self-reported handwashing frequency and technique, and on use of hand disinfectants, in German $adults^{S,S}$.

	Women			Men		
	N	%	95%-CI	N	%	95%-CI
Attribute "Frequence Facet "After toilet"	:y"					
Almost always	2070	98.1	97.4–98.9	1885	95.1	94.1–96.0
Mostly	32	1.5	1.1 - 2.1	84	4.2	3.4–5.2
Seldom	6	0.3	0.1–0.6	6	0.3	0.1-0.6
Never	4	0.2	0.1–0.4	7	0.3	0.2–0.7
Facet "Before prepart	ig meals"	97 4	95 0 99 7	1600	80.7	70 0 82 4
Mostly	218	10.3	9.0_11.7	243	12.3	10.9-13.8
Seldom	33	1.6	1.1-2.2	102	5.1	4.2-6.2
Never	16	0.8	0.5–1.2	37	1.9	1.3-2.5
Facet "After being with	h ill persor	1"				
Almost always	1581	74.9	73.0–76.7	1260	63.6	61.4–65.7
Mostly	285	13.5	12.1–15.0	317	16.0	14.4–17.7
Seldom	141	6.7	5.7-7.8	261	13.2	11.7–14.7
Never Easet "Pofore eating"	103	4.9	4.0–5.9	144	7.2	6.2-8.5
Almost always	1420	67 7	65 7-69 66	1220	61 5	59 4 63 7
Mostly	429	20.3	18.7-22.1	423	21.4	19.6-23.2
Seldom	190	9.0	7.8–10.3	260	13.1	11.7–14.7
Never	63	3.0	2.3-3.8	79	4.0	3.2-4.9
Facet "After contact w	rith pet"					
Almost always	1184	56.1	54.0-58.2	887	44.8	42.6-47.0
Mostly	413	19.6	17.9–21.3	421	21.2	19.5-23.1
Seldom	340	16.1	14.6–17.7	436	22.0	20.2-23.9
Never	173 11 nomon "	8.2	7.1–9.4	238	12.0	10.6–13.5
Almost always	1148	54 4	52 3-56 5	864	43.6	41 4 45 8
Mostly	348	16.5	15.0-18.1	341	17.2	15.6-18.9
Seldom	281	13.3	11.9–14.8	414	20.9	19.1–22.7
Never	334	15.8	14.3-17.4	362	18.3	16.6-20.0
Facet "After coming h	ome"					
Almost always	1166	55.2	53.1–57.4	842	42.5	40.3–44.7
Mostly	432	20.5	18.8-22.2	428	21.6	19.8-23.5
Seldom	339	16.1	14.5–17.7	492	24.8	23.0-26.8
Never	174	8.3 "	7.1–9.5	220	11.1	9.8–12.5
Almost always	e or cougn 777	36.8	34 8 38 9	460	<u> </u>	21 4_25 1
Mostly	547	25.9	24.1-27.8	464	23.4	21.4-25.3
Seldom	559	26.5	24.6-28.5	712	35.9	33.8-38.1
Never	226	10.7	9.4–12.1	346	17.5	15.8–19.2
Facet "After handshak	e"					
Almost always	193	9.2	7.8–10.4	120	6.0	5.1 - 7.2
Mostly	252	11.9	10.6-13.4	159	8.0	6.9–9.3
Seldom	908	43.0	40.9-45.1	873	44.0	41.9-46.2
Attribute "Technia	/ 38 1e"	35.9	33.9-38.0	830	42.0	39.7-44.1
Facet "Soap"						
Always soap or	1810	85.8	84.2-87.2	1746	88.1	86.6-89.5
wash lotion						
Mostly only clear water	91	4.3	3.5–5.2	82	4.1	3.3–5.1
Differently every time	209	9.9	8.7–11.2	155	7.8	6.7–9.1
Facet "Drying"	1540	70.4	71 5 75 0	1590	77.0	
Almost always	1549 358	73.4	71.5-75.2	1530	15.2	75.3-79.0
Seldom	116	5.5	4 6-6 5	502 61	3.1	2.4-3.9
Never	87	4.1	3.3–5.0	89	4.5	3.6-5.5
Facet "Spaces"						
Almost always	1323	62.7	60.6-64.7	1349	68.1	66.0-70.1
Mostly	489	23.2	21.4-25.0	369	18.6	17.0-20.4
Seldom	245	11.6	10.3-13.0	225	11.3	10.0 - 12.8
Never	54	2.6	1.9–3.3	38	1.9	1.4–2.6
Use of hand disinfe	ctants	10.6	11 0 14 1	140	7 5	6 4 09 7
Only in certain	200 772	12.0 36.6	11.2–14.1 34 5 <u>–</u> 38 7	149 581	7.5 29.3	0.4-08./ 27 3_31 4
situations	//2	50.0	57.5-50.7	301	27.3	27.5-31.7
Never	1072	50.8	48.7–52.9	1252	63.2	61.0-65.3

Notes: [§] Any differences to results in BZgA (2013) due to differences in exclusion criteria applied (for details, see *Sample description*) [§] Categories formatted in **bold format** considered as self-reported compliance.

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Table 3

Distributions of single and combined attributes of self-reported handwashing behavior in German adults.

ATTRIBUTES N % 95%-CI N % 95%-CI Frequency ^{8,5} 7-9 compliant 650 30.8 28.9–32.8 403 20.3 18.6–22.2 indications 1103 52.3 50.1–54.4 955 48.2 46.0–50.4 indications 350 16.6 15.1–18.2 590 29.8 27.8–31.8 indications 350 16.6 15.1–18.2 590 29.8 27.8–31.8 indications 7 0.3 0.1–0.6 34 1.7 1.2–2.4 indications 917 43.5 41.3–45.6 1011 51.0 48.8–53.2 technical facets 7 3.3 2.6–4.1 48 2.4 <td< th=""></td<>	
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Notes: [§]: For details, see **2.2.** *Measures: items and indices* and Table S1; ^{\$}: Categories formatted in **bold format** considered as self-reported compliance.

the difference between respondents working in healthcare vs. not. Regarding handwashing compliance, ORs ranged from 1.8 (frequency as well as frequency and technique combined) to 2.5 (technique and duration combined) among women and from 1.5 (technique) to 3.0 (combination of frequency and duration) among men, all indicating higher compliance among healthcare workers (Table 5). Differences in regular use of hand disinfectants were even more pronounced. Comparing respondents currently working vs. not, regardless of healthcare, significant differences indicated lower handwashing compliance in those working for frequency (women and men), duration (men), and combinations of frequency and technique (women), and frequency and duration (men). Significantly higher rates in those working pertained to technique (men) and the use of hand disinfectants (women).

Respondents with a migration background reported a higher frequency of handwashing both in women and men, albeit on different levels. Correspondingly, higher rates were found for the combination of frequency and technique as well as frequency and duration (men only), while differences for frequency, technique and duration combined were smaller and insignificant. This trend also held for regular use of hand disinfection.

Reported compliance rates by and large did not significantly co-vary by children living in the household vs. not. Actually, the only significant difference among both women and men was found for handwashing frequency in terms of lower compliance in respondents from a household with children. Among men, a similar assertion held for handwashing duration.

Finally, regarding recall of handwashing instruction plates in public restrooms, ORs for all hand hygiene parameters were greater than 1. For compliance with technique and the combination of frequency and technique among women as well as duration and frequency and duration combined among men, no statistically significant associations were observed (the OR for frequency among men was significant, but reflected uniform compliance rates of 20.2%). The highest OR was determined for use of hand disinfectants among men (2.5; see Table 5), reflecting a bi-variate difference between 12.2% and 4.9% (Table 4). Regarding handwashing, the highest ORs also pertained to men. For women, the highest OR was found for frequency (single attribute).

4. Discussion

The results of the present analysis can be summarized as follows. Related to the paper's first aim, self-reported compliance rates varied between single-digits and near ubiquity for single facets of handwashing frequency, and between two-thirds to nine-tenths for single technical facets. In contrast, rates based on combinations of facets approximately varied between two-to three-tenths for frequency, and four-to fivetenths for technique. Regarding combinations of attributes, i.e., indices based on more than one of frequency, technique, and duration, compliance rates were even lower, varying from one-to two-tenths given two attributes, and in single-digit range for the index based on all attributes.

Regarding the second aim, two clusters of results stand out. First, among socio-demographics, the trends to higher levels of handwashing in the sub-groups with higher age and lower formal education level add to the inconsistent or mixed results recently determined for these associations (White et al., 2020). This may at least partly reflect associations with social desirability reported among German adults, which tends to increase with age, and to be lower given lower education (Haberecht et al., 2015). The higher compliance rates found for respondents with a migration background are consistent with White et al. (2020). Additionally, the positive association of working in healthcare with handwashing compliance was consistent, i.e., found for indices based on single or combined attributes, and was even more strongly linked to hand disinfectants use. Second, the results for recall of handwashing instructions showed noteworthy patterns. Associations with handwashing compliance were generally stronger among men. Additionally, among single attributes, in addition to frequency, technique among men and to a lesser degree duration among women was associated with recall. This notion was also reflected in the indices based on combined attributes. On the other hand, among men, the strongest association was found with hand disinfectant use, the odds of which were increased by 2.5 even though these plates do not include information on disinfection.

Before further discussion, strengths and limitations of the study must be considered. On the plus side, publicly available data from a representative general population survey commissioned by a national

Table 4

7

Self-reported handwashing compliance based on single and combined attributes, and self-reported regular use of hand disinfectants (for comparison), in German adults, in subgroups.

WOMEN	Hand	washin	g compliance	e based	on sing	le attributes [§]				Hand	washin	g compliance	based	on com	ibined attribu	ites						Regu	lar use	of hand
	Frequ	iency		Tech	nique		Dura	tion		Frequ	iency +	Technique	Frequ	iency +	Duration	Tech	nique +	Duration	Frequ + Du	uency + iration	Technique	disin	fectants	8
	N	%	95%-CI	N	%	95%-CI	N	%	95%-CI	N	%	95%-CI	N	%	95%-CI	N	%	95%-CI	N	%	95%-CI	N	%	95%-CI
Age																								
60-85 years	209	33.8	30.2-37.6	273	44.1	40.2-48.0	212	34.2	30.6 - 38.1	129	20.8	17.8-24.2	84	13.5	11.1 - 16.5	127	20.5	17.5–23.9	64	10.3	8.2 - 13.0	35	5.6	4.1–7.8
45–59 years	162	28.0	24.5-31.8	271	46.8	42.8-50.1	208	36.0	32.2-40.0	97	16.8	13.9-20.0	67	11.6	9.2–14.4	115	19.9	16.9-23.3	48	8.3	6.3 - 10.8	81	14.0	11.4–17.1
30-44 years	149	29.3	25.5-33.4	211	41.5	37.3-45.8	174	34.1	30.1-38.3	83	16.3	13.4–19.8	74	14.5	11.7–17.9	102	20.0	16.8-23.7	44	8.6	6.5–11.4	60	11.8	9.3–14.9
16-29 years	130	32.2	27.8-36.9	163	40.3	35.6-45.2	121	30.0	25.6-34.6	63	15.6	12.3–19.4	51	12.6	9.7–16.1	67	16.6	13.2-21.5	29	7.2	4.9–10.0	90	22.3	18.5 - 26.6
Educational backgro	ound																							
low (secondary general school)	333	39.3	36.0-42.6	357	42.1	38.8-45.5	287	33.8	30.7–37.1	167	19.7	17.2–22.5	125	14.7	12.5–17.3	160	18.8	16.4–21.6	73	8.6	6.9–10.7	100	11.8	9.8–14.1
medium (intermediate school)	182	25.1	22.1–28.4	351	48.5	44.9–52.1	254	35.1	31.2–38.6	129	17.8	15.2–20.8	93	12.8	10.6–15.5	160	22.1	19.2–26.3	71	9.8	7.8–12.2	109	15.1	12.6–17.8
high (upper secondary school)	132	25.0	21.5-28.9	204	38.7	34.7–42.9	168	31.9	28.0-36.0	74	14.0	11.3–17.3	57	10.8	8.4–13.8	88	16.7	13.8–20.1	41	7.8	5.8–10.4	56	10.6	8.3–13.6
Currently working																								
Yes	284	26.4	23.9 - 29.1	473	44.0	41.0-46.9	374	34.8	32.0-37.7	167	15.5	13.5–17.8	141	13.1	11.2–15.3	215	20.0	17.7-22.5	91	8.5	6.9 - 10.3	195	18.1	15.9 - 20.5
No	347	35.5	32.5-38.5	423	43.3	40.2-46.4	326	33.3	30.5-36.4	195	20.0	17.6-22.6	129	13.2	11.2 - 15.5	189	19.3	17.0-22.0	91	9.3	7.6–11.3	70	7.2	5.7-8.9
Healthcare worker																								
Yes	106	35.3	30.1-40.9	172	57.3	51.2-62.8	145	48.3	42.3-54.0	66	22.1	17.7 - 27.1	65	21.7	17.4-26.7	96	32.0	27.0-37.4	40	13.4	10.0 - 17.7	111	37.1	31.8-42.7
No	545	30.1	28.0 - 32.2	745	41.1	38.9-43.4	570	31.5	29.4-33.7	306	16.9	15.2 - 18.7	211	11.6	10.3 - 13.2	316	17.4	15.8-19.3	145	8.0	6.8–9.3	155	8.6	7.4–9.9
Migration backgrou	nd																							
Yes	193	44.1	39.5-48.7	193	44.1	39.5-48.7	123	28.1	24.1 - 32.5	105	24.0	20.2 - 28.2	65	14.8	11.8 - 18.5	67	15.3	12.2-19.0	46	10.5	8.0-13.7	69	15.8	12.6-19.5
No	457	27.4	25.3-29.6	724	43.4	41.0-45.8	592	35.5	33.2-37.8	266	15.9	14.3–17.8	210	12.6	11.1-14.3	345	20.7	18.8-22.7	140	8.4	7.2–9.8	197	11.8	10.3-13.4
Children in the hou	sehold																							
Yes	171	28.4	25.0 - 32.1	254	42.3	38.4-46.3	197	32.7	29.1-36.6	105	17.5	14.6-20.7	76	12.6	10.2 - 15.5	116	19.3	16.4-22.7	49	8.1	6.2 - 10.6	75	12.5	10.1 - 15.3
No	476	31.7	29.4-34.1	660	43.9	41.4-46.4	516	34.3	32.0-36.8	265	17.6	15.8-19.6	198	13.2	11.6-15.0	295	19.6	17.7-21.7	135	9.0	7.6-10.5	190	12.6	11.1-14.4
Recall of handwash	ing ins	tructio	n plates in p	oublic	restroo	ms																		
At least once	310	36.6	33.4-40.0	380	44.8	41.5-48.2	315	37.1	34.0-40.5	158	18.6	16.2-21.4	132	15.6	13.3 - 18.2	183	21.6	18.9-24.5	84	9.9	8.1 - 12.1	142	16.8	14.4–19.4
No	337	26.8	24.5-29.4	533	42.5	39.7-45.2	399	31.8	29.3–34.4	211	16.8	14.8–19.0	142	11.3	9.7–13.2	228	18.2	16.1-20.4	100	8.0	6.6–9.6	123	9.8	8.3–11.6

MEN	Hand	lwashi	ng complian	ce bas	ed on s	ingle attribu	ıtes [§]			Hane	dwashi	ng complian	ce bas	ed on c	ombined att	ribute	s					Regu	lar use	of hand
-	Freq	uency		Tech	nique		Dura	ition		Freq Tech	uency - nique	ł	Freq	uency -	+ Duration	Tech	nique -	+ Duration	Freq Tech	uency mique	+ + Duration	disin	fectant	s [§]
_	Ν	%	95%-CI	Ν	%	95%-CI	Ν	%	95%-CI	Ν	%	95%-CI	Ν	%	95%-CI	Ν	%	95%-CI	Ν	%	95%-CI	N	%	95%-CI
Age																								
60-85 years	122	24.7	21.1 - 28.7	263	53.5	49.0-57.8	222	45.1	40.8-49.5	75	15.2	12.3–18.7	67	13.6	10.9–16.9	126	25.6	21.6-29.6	38	7.7	5.7 - 10.4	31	6.3	4.5-8.8
45-59 years	141	25.0	21.6 - 28.7	260	46.2	42.1-50.3	260	46.1	42.0-50.2	71	12.6	10.1 - 15.6	81	14.4	11.7–17.5	121	21.5	18.3-25.0	38	6.7	4.9-9.1	47	8.3	6.3–10.9
30-44 years	77	15.3	12.4–18.7	268	53.1	48.7–57.4	153	30.3	26.5-34.4	46	9.1	6.9–11.9	25	5.0	3.4–7.2	105	20.8	17.5–24.6	17	3.4	2.1 - 5.3	47	9.3	7.1–12.2
16-29 years	63	15.0	11.8 - 18.6	220	52.1	47.4–57.9	108	25.7	21.7-29.9	53	12.6	9.7–16.0	36	8.6	6.2 - 11.5	63	14.9	11.8-18.6	32	7.6	5.3 - 10.4	25	5.9	3.9-8.5
Educational backgr	ound																							
low (secondary general school)	190	22.9	20.1-25.8	469	56.4	53.1–59.8	350	42.1	38.8–45.5	116	14.0	11.8–16.5	99	11.9	9.9–14.3	190	22.9	20.1-25.8	52	6.3	4.8-8.1	45	5.4	4.1–7.2
medium (intermediate school)	117	23.0	19.5–26.8	260	51.1	46.5–55.4	196	38.5	34.4–42.8	73	14.3	11.6–17.7	60	11.8	9.3–14.9	114	22.4	19.0–26.2	39	7.7	5.7–10.3	53	10.4	8.0–13.4
high (upper secondary school)	92	14.6	12.1–17.6	275	43.7	39.9–47.6	192	30.5	27.1–34.2	55	8.7	6.8–11.2	49	7.8	5.9–10.2	107	17.0	14.3–20.2	34	5.4	3.9–7.5	49	7.8	5.9–10.2
Currently working																								
Yes	228	18.9	16.0 - 20.3	673	53.2	50.1 - 56.0	448	35.4	32.9 - 38.1	151	11.9	10.3 - 13.9	108	8.5	7.1 - 10.2	266	21.0	18.9–23.4	80	6.3	5.1 - 7.8	114	9.0	7.6–10.7
No	164	24.1	21.0-27.4	332	48.8	45.0–52.5	288	42.4	38.6-46.0	93	13.7	11.3–16.4	99	14.5	12.1 - 17.4	145	21.3	18.4–24.5	43	6.3	4.7-8.4	32	4.7	3.3–6.6
																						(con	tinued o	n next page)

Fable 4 (continued)

(nonimica) - arana																								
WOMEN	Hand	lwashin	g compliance	e based	on sing	le attributes §				Hand	washing	compliance	based o	on coml	oined attribute	SS						Regula	ir use of	f hand
	Frequ	uency		Tech	nique		Durat	uoi		Frequ	ency +	Technique	Frequ	ency +	Duration	Techni	ique + 1	Juration	Freque + Dur	ency + 1 ation	echnique	disinfe	ctants	
	z	%	95%-CI	z	%	95%-CI	z	%	95%-CI	z	%	95%-CI	z	%	95%-CI	N	%	95%-CI	z	%	95%-CI	z	%	95%-CI
Healthcare worker																								
Yes	29	28.7	20.8-38.2	59	59.0	49.2 - 68.1	54	53.5	43.8-62.9	20	20.0	13.3 - 28.9	20	20.0	13.3 - 28.9	30	30.0	21.9–39.6	12	12.0	7.0-19.8	35	35.0	26.4-44.7
No	374	19.9	18.1 - 21.7	952	50.6	48.4–52.9	690	36.7	34.5 - 38.9	225	12.0	10.6 - 13.5	189	10.0	8.8-11.5	384	20.4	18.7 - 22.3	112	6.0	5.0 - 7.1	114	6.1	5.1 - 7.2
Migration backgrou	pu																							
Yes	66	25.9	21.8 - 30.5	184	48.2	43.2–53.2	144	37.6	32.9-42.6	59	15.4	12.1 - 19.4	52	13.6	10.5 - 17.4	66	17.2	13.8-21.3	25	6.5	4.5–9.5	28	7.3	5.1 - 10.4
No	303	18.9	17.1 - 21.0	827	51.7	49.3–54.2	600	37.5	35.2–39.9	187	11.7	10.2 - 13.4	157	9.8	8.5-11.4	348	21.8	19.8 - 23.9	66	6.2	5.1 - 7.5	121	7.6	6.4-9.0
Children in the hou	sehold																							
Yes	66	15.4	12.3-19.2	196	45.8	41.1 - 50.5	158	36.9	32.5-41.6	48	11.2	8.6 - 14.6	29	6.8	4.8-9.6	60	21.0	17.4 - 25.1	21	4.9	3.2-7.4	49	11.4	8.8-14.8
No	335	21.7	19.7 - 23.8	813	52.7	50.2 - 55.2	578	37.5	35.1–39.9	196	12.7	11.1 - 14.5	179	11.6	10.1 - 13.3	323	20.9	19.0 - 23.1	103	6.7	5.5 - 8.0	98	6.3	5.2 - 7.7
Recall of handwash	ing ins	tructio	n plates in p	public	restrooi	su																		
At least once	141	20.2	17.4 - 23.3	398	56.9	53.2 - 60.5	258	36.9	33.4-49.6	108	15.4	12.9–18.3	69	9.9	7.9–12.3	165	23.6	20.6–26.9	53	7.6	5.8-9.8	85	12.2	9.9–14.8
No	257	20.2	18.1 - 22.5	608	47.7	45.1–50.1	479	37.6	35.0-40.3	135	10.6	9.0–12.4	135	10.6	9.0–12.4	246	19.3	17.3–21.6	68	5.3	4.2–6.7	62	4.9	3.8-6.2
Note: [§] Any different	to r	esults	in BZgA (20	013) di	ue to d	ifferences in	exclu	sion cri	iteria applié	id (for	details	s, see Samp	ole des	cription	1).									

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governmental specialist authority using a multitude of attributes and facets of handwashing were analysed. Additionally, studies on handwashing behaviour and its determinants from high-income countries are still more infrequent than those from middle- or low-income countries (White et al., 2020). Using data from Germany, this study adds to the global current state of research.

Several limitations also exist. First, the overall survey response rate was 49.7% (calculation based on BZgA, 2013, 2015) and even lower in the cellular mobile sampling frame (38.7%). While such response rates are common in population surveys in Europe (Beullens et al., 2018), the present results may have been affected by selection biases, especially as the survey was on, among other things, hygiene behaviour, which may represent a potentially sensitive topic for some. Additionally, the lower rate in the mobile sampling frame may predominantly have affected younger adults. Both may limit the generalizability (external validity) of the results to the German population as a whole. Second, not all facets of handwashing technique were covered. On the one hand, the use of clean and running water before and after applying soap or wash lotion should also be assessed. On the other hand, participants were asked if they washed their hands between the fingers, i.e., interdigital spaces, while recommendations suggest washing all parts of the hands (BZgA, 2020). Third, both the frequency and the technical facets were weighted equally, i.e., the value 1 was added to the index for every compliant facet. While this admittedly is a simplifying procedure, we are not aware of data quantitatively suggesting other weights, e.g., in relation to effectiveness. Fourth, the present data reflect the situation in Germany in 2012, and analyses should be replicated with more recent data (BZgA, 2018), especially to elucidate the effects of more recent epidemics, i.e., influenza in 2017/18 and the COVID-19 pandemic in 2020. Fifth, the survey was cross-sectional, so reverse causality cannot be rule out. This especially holds for the associations of self-reported handwashing with the recall of handwashing instruction plates in public restrooms. Thus, it is entirely possible that men who compliantly wash their hands (or at least self-report this) are more prone to remember these prompts, not the other way around. However, the associations found show that self-reported compliance and recollection are not completely unrelated, which would have suggested complete irrelevance of these prompts. Finally, and in relation to the former limitation, the present data are self-reports of hand hygiene. Thus, on one hand, they obviously do not claim to correspond to assessments based on observation. On the other, possible reporting biases in terms of differential reporting tendencies have to be taken into account. E.g., in contrast to others (White et al., 2020), we did not find women to be more likely to wash their hands with soap. This may be due to men's stronger propensity to falsely self-report preventive behaviours, as shown for, e.g., colorectal cancer screening use (Griffin et al., 2009). Thus, feedback to men of their over-estimation may even be more important than that for women.

Keeping these limitations in mind, the main impetus of the present paper was to provide an in-depth analysis of handwashing compliance based on self-reported handwashing frequency, duration, and technique. By doing so, it aimed to contribute to the development of direct selfreport measures that are less restricted to the frequency attribute and less susceptible to overestimation or at least more assessable regarding the level of overestimation. The most recent and pertinent analysis for use as reference for the survey data presented here is the meta-analysis by Wolf et al. who pooled data from handwashing prevalence studies that used observation to assess the behaviour (Wolf et al., 2019a). For Germany, they estimated a prevalence of 48.7% for handwashing with soap (technique) after potential faecal contact, including visiting the toilet (frequency by indication), which was the only index they reported for individual countries. For comparison, we calculated the self-reported compliance rate for the combination of facets available in the present study which is most similar to that used by Wolf et al., i.e., "use of soap or wash lotion" and "after using the toilet". For this combination, a rate of 84.1% was found, which indicates an overestimation by 1.726 when compared to the rate based on observation as reported by Wolf et al. (i.

Table 5

9

Results of multiple logistic regression analyses for handwashing compliance based on single and combined attributes, and for regular use of hand disinfectants (for comparison)[§].

WOMEN	Han	dwashing	compliar	ice bas	sed on sin	gle attrib	utes			Han	dwashing	complia	ice ba	sed on cor	nbined at	ttribut	es		-			Regu	ılar use of	hand
	Freq	uency		Tech	nique		Dura	ntion		Freq Tech	uency + mique		Freq	uency + I	Duration	Tech	inique + I	Duration	Freq Tech	luency + nique + I	Duration	disin	fectants	
	OR	95%- CI	р	OR	95%- CI	р	OR	95%- CI	р	OR	95%- CI	р	OR	95%- CI	р	OR	95%- CI	р	OR	95%- CI	р	OR	95%-CI	р
Age																								
60-85 years	1.2	0.9–1.7	=	1.4	1.0–1.9	=	1.4	1.0 - 2.0	=	1.8	1.2 - 2.8	=	1.4	0.9–2.2	= 0.170	1.6	1.1 - 2.3	=	2.1	1.2–3.6	=	0.3	0.2–0.6	<
45-59 years	1.1	0.8–1.5	=	1.4	1.1–1.9	=	1.5	1.1 - 2.0	=	1.5	1.0-2.2	=	1.1	0.7–1.7	=	1.3	0.9–1.9	=	1.5	0.9–2.5	=	0.6	0.4–0.8	=
			0.483			0.011			0.012			0.042			0.666			0.114			0.132			0.003
30–44 years	1.3	0.9–1.8	= 0.109	1.1	0.8–1.5	= 0.460	1.4	1.0–1.9	= 0.044	1.2	0.8–1.9	= 0.281	1.5	1.0 - 2.3	= 0.050	1.4	0.9–2.0	= 0.097	1.5	0.9–2.5	= 0 144	0.5	0.3–0.8	= 0.001
16–29 years	ref.		0.109	ref.		0.400	ref.		0.044	ref.		0.201	ref.		0.050	ref.		0.057	ref.		0.144	ref.		0.001
Educational backgrou	nd																							
low (secondary	2.0	1.5–2.6	<	1.1	0.9–1.4	= 0.357	1.2	0.9–1.5	= 0.225	1.3	1.0 - 1.8	=	1.6	1.1–2.3	=	1.2	0.9–1.6	= 0.208	1.1	0.7–1.6	= 0.785	1.9	1.3–2.8	=
medium (intermediate	1.1	0.8-1.4	=	1.4	1.1-1.8	=	1.2	0.9–1.5	=	1.3	0.9–1.8	=	1.3	0.9–1.9	=	1.4	1.0-1.9	=	1.3	0.8–1.9	=	1.8	1.2-2.6	=
school)			0.528			0.002			0.173			0.138			0.150			0.024			0.267			0.002
high (upper secondary	ref.			ref.			ref.			ref.			ref.			ref.			ref.			ref.		
Currently working																								
Yes	0.7	0.5–0.8	=	0.9	0.7 - 1.1	=	0.9	0.7 - 1.1	=	0.7	0.5 - 1.0	=	0.9	0.6–1.2	=	0.8	0.6–1.1	=	0.8	0.6–1.2	=	1.8	1.3–2.7	=
No	rof		0.001	rof		0.203	rof		0.263	rof		0.030	rof		0.377	rof		0.256	rof		0.336	rof		0.001
Healthcare worker	Ter.			iei.			iei.			iei.			iei.			iei.			iei.			iei.		
Yes	1.8	1.3–2.3	<	2.1	1.6–2.7	<	2.2	1.7–2.9	<	1.8	1.3 - 2.5	<	2.4	1.7–3.4	<	2.5	1.9–3.4	<	2.1	1.4–3.1	=	4.2	3.1–5.7	<
No	nof		0.001	nof		0.001	nof		0.001	nof		0.001	nof		0.001	nof		0.001	nof		0.001	nof		0.001
NO Migration background	rei.			rer.			rer.			reī.			rei.			rei.			rer.			rei.		
Yes	2.1	1.7 - 2.7	<	1.1	0.9–1.4	=	0.7	0.6–0.9	=	1.9	1.4–2.4	<	1.3	0.9–1.7	=	0.7	0.5-0.9	=	1.4	1.0 - 2.0	=	1.3	1.0 - 1.8	=
No	nof		0.001	nof		0.498	nof		0.005	nof		0.001	nof		0.168	nof		0.013	nof		0.065			0.093
Children in the house	rei. 10ld			rei.			rei.			rei.			rei.			rei.			rei.			rei.		
Yes	0.7	0.6–0.9	=	1.0	0.8–1.3	=	0.9	0.7 - 1.2	=	1.1	0.8-1.5	=	0.8	0.6–1.1	=	1.1	0.8-1.4	=	0.9	0.6–1.4	=	0.8	0.5–1.1	=
	c		0.017	c		0.707	c		0.566	c		0.543	c		0.236	c		0.724	c		0.750	c		0.110
NO Recall of handwashing	ret.	uction pla	ites in nu	ret. blic re	strooms		ref.			ref.			ref.			ref.			ref.			ref.		
At least once	1.7	1.4-2.1	<	1.2	1.0–1.4	-	1.4	1.1 - 1.7	=	1.2	0.9–1.6	=	1.5	1.2-2.0	=	1.4	1.1 - 1.8	=	1.5	1.1 - 2.1	-	1.4	1.1–1.9	=
	c		0.001	c		0.122	c		0.002	c		0.124	c		0.003	c		0.008	c		0.018	c		0.016
Never MEN	ref. Hand	dwashing	compliar	ret.	sed on sin	ele attrib	ret.			ref. Han	dwashing	complia	ref. ice ba	sed on cor	nbined at	ret. ttribut	es		ref.			ref. Regi	ılar use of	hand
	Fred	Hency		Tech	nique	B	Dur	ation		Fred	liency		Fred		Juration	Tech	nique ⊥D	Juration	Fred	ulency ⊥		disin	fectants	
	ricq	ucity		reen	inique		Dur	liton		+Te	chnique		ricq	ucity +E	uration	ittei	inque +b	uration	Tech	nique + I	Duration			
	OR	95%-	р	OR	95%-	р	OR	95%-	р	OR	95%-	р	OR	95%-	р	OR	95%-	р	OR	95%-	р	OR	95%-CI	р
		CI	-		CI	•		CI	-		CI	-		CI	-		CI	-		CI	-			-
Age																								
60-85 years	1.7	1.2 - 2.5	=	1.2	0.9–1.7	=	2.2	1.6 - 3.0	<	1.7	1.1 - 2.7	=	1.4	0.8 - 2.2	=	2.2	1.5 - 3.2	<	1.5	0.8–2.6	=	1.9	1.0 - 3.5	=
45-59 years	2.0	1.4-2.9	0.007	0.7	0.5-0.9	0.166 =	2.4	1.8-3.2	0.001 <	1.0	0.7-1.5	0.016	2.0	1.3-3.1	0.211	1.4	1.0 - 2.1	0.001	0.8	0.5-1.3	0.181	1.0	0.6–1.7	0.053
			0.001			0.004		0.2	0.001		1.0	0.913		0.1	0.003			0.038	2.0	110	0.324			0.903
30-44 years	1.1	0.8 - 1.7	=	1.0	0.7 - 1.3	=	1.2	0.9–1.7	=	0.6	0.4–0.9	=	0.6	0.3 - 1.1	=	1.4	0.9–2.0	=	0.3	0.1–0.6	<	1.0	0.6–1.8	=
16-29 years	ref.		0.534	ref.		0.737	ref.		0.209	ref.		0.020	ref.		0.090	ref.		0.108	ref.		0.001	ref.		0.906
- y																						(con	ntinued on r	next page)

WOMEN	Han	dwashing	complia	nce ba	sed on sin	gle attril	outes			Han	dwashing	complia	nce ba	sed on con	nbined at	tribut	es					Regu	ılar use of	hand
	Freq	luency		Tech	ınique		Dura	ation		Freq Tecl	uency + nique		Freq	uency + I	Duration	Tech	hnique + I	Duration	Frec Tecl	luency + nnique + I	Duration	disir	ifectants	
	OR	95%- CI	р	OR	95%- CI	р	OR	95%- CI	р	OR	95%- CI	р	OR	95%- CI	р	OR	95%- CI	р	OR	95%- CI	р	OR	95%-CI	р
Educational backgrou	nd																							
low (secondary general school)	1.7	1.3–2.2	= 0.001	1.9	1.5–2.4	< 0.001	1.7	1.4–2.2	< 0.001	1.8	1.3–2.6	= 0.001	1.6	1.1–2.3	= 0.020	1.5	1.2-2.0	= 0.002	1.2	0.7–1.9	= 0.527	1.0	0.6–1.6	= 0.975
medium (intermediate school)	1.9	1.4–2.6	< 0.001	1.5	1.2–1.9	= 0.001	1.5	1.1–1.9	= 0.003	2.0	1.4–2.9	< 0.001	1.7	1.1–2.6	= 0.013	1.5	1.1–2.0	= 0.010	1.6	1.0–2.6	= 0.069	1.6	1.0-2.5	= 0.042
high (upper secondary school) Currently working	ref.			ref.			ref.			ref.			ref.			ref.			ref.			ref.		
Yes	0.7	0.5–1.0	= 0.023	1.6	1.2–2.0	= 0.001	0.7	0.6–1.0	= 0.025	1.2	0.8–1.7	= 0.422	0.5	0.4–0.8	= 0.001	1.1	0.8–1.6	= 0.420	1.5	0.9–2.5	= 0.113	1.6	0.9–2.8	= 0.081
No	ref.			ref.			ref.			ref.			ref.			ref.			ref.			ref.		
Healthcare worker																								
Yes	2.0	1.2–3.3	= 0.005	1.5	1.0–2.4	= 0.055	2.1	1.4–3.3	= 0.001	2.0	1.1–3.5	= 0.018	3.0	1.7–5.5	< 0.001	1.6	1.0–2.6	= 0.056	1.8	0.9–3.9	= 0.107	7.9	4.7–13.2	< 0.001
No	ref.			ref.			ref.			ref.			ref.			ref.			ref.			ref.		
Migration background	1																							
Yes	1.8	1.3–2.3	< 0.001	0.8	0.7–1.1	= 0.150	1.1	0.9–1.4	= 0.466	1.7	1.2–2.3	= 0.004	1.7	1.2–2.4	= 0.006	0.8	0.6–1.1	= 0.111	1.3	0.8–2.2	= 0.235	1.2	0.7–1.9	= 0.460
No	ref.			ref.			ref.			ref.			ref.			ref.			ref.			ref.		
Children in the house	hold																							
Yes	0.7	0.5–1.0	= 0.049	0.7	0.6–0.9	= 0.007	1.2	1.0–1.6	= 0.083	1.0	0.7–1.5	= 0.849	0.7	0.4–1.1	= 0.080	1.1	0.8–1.5	= 0.544	0.9	0.5–1.5	= 0.632	1.5	1.0-2.3	= 0.077
No	ref.			ref.			ref.			ref.			ref.			ref.			ref.			ref.		
Recall of handwashin	g instr	uction pla	ates in pu	iblic re	estrooms																			
At least once	1.3	1.0–1.7	= 0.038	1.6	1.3–2.0	< 0.001	1.1	0.9–1.4	= 0.272	1.9	1.4–2.5	< 0.001	1.2	0.9–1.7	= 0.300	1.5	1.2–1.9	= 0.001	1.7	1.2–2.5	= 0.008	2.5	1.7–3.6	< 0.001
Never	ref.			ref.			ref.			ref.			ref.			ref.			ref.			ref.		

Note: [§]OR: odds ratio; CI: confidence interval; all estimates are from the multiple logistic regression model for each respective behavioural indicator, which included all predictors listed (i.e. age, educational background, current work status, working in healthcare, migration background, children in the household, and recall of handwashing instruction plates in public restrooms).

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org/10.1016/j.ijheh.2020.113590.

References

- Adm Arbeitskreis Deutscher Markt- und Sozialforschungsinstitute, 1999. In: Stichproben-Verfahren in der Umfrageforschung: Eine Darstellung für die Praxis. Leske + Budrich, Opladen.
- Aiello, A.E., Coulborn, R.M., Perez, V., Larson, E.L., 2008. Effect of hand hygiene on infectious disease risk in the community setting: a meta-analysis. Am. J. Public Health 98, 1372–1381.
- Beullens, K., Loosveldt, G., Vandenplas, C., Stoop, I., 2018. Response rates in the European Social Survey: increasing, decreasing, or a matter of fieldwork efforts? Survey Methods. https://doi.org/10.13094/SMIF-2018-00003.
- Bradburn, N.M., 2000. Temporal representation and event dating. In: Stone, A.A., Turkkan, J.S., Bachrach, C.A., Jobe, J.B., Kurtzman, H.S., Cain, V.S. (Eds.), The science of self-report: implications for research and practice. Lawrence Erlbaum Associates, Mahwah, pp. 49–61.
- BZgA, 2013. Einstellungen, Wissen und Verhalten der Allgemeinbevölkerung zu Hygiene und Infektionsschutz. BZgA, Cologne.
- BZgA, 2015. Infektionsschutz 2012: ZA5175 Datenfile Version 1.0.0 GESIS Datenarchiv. Cologne. https://search.gesis.org/research data/ZA5175 (accessed 08.04.2020).
- BZgA, 2018. Infektionsschutz durch Hygiene: Einstellungen, Wissen und Verhalten der Allgemeinbevölkerung – Ergebnisse der Repräsentativbefragung 2017. BZgA, Cologne.
- BZgA, 2020. Wichtige Hygienetipps. BZgA. Cologne. https://www.infektionsschutz. de/coronavirus/schutz-durch-hygiene.html (accessed 08.04.2020).
- Chamberlain, A.N., Halablab, M.A., Gould, D.J., Miles, R.J., 1997. Distribution of bacteria on hands and the effectiveness of brief and thorough decontamination procedures using non-medicated soap. Zentralbl. Bakteriol. 285, 565–575.
- Contzen, N., De Pasquale, S., Mosler, H.J., 2015. Over-reporting in handwashing selfreports: potential explanatory factors and alternative measurements. PloS One 10, e0136445.
- Dean, A.G., Soe, M.M., 2013. OpenEpi: Open Source Epidemiologic Statistics for Public Health, Version 3.01. Emory University. www.openepi.com (accessed 08.08.2020).
- Diefenbacher, S., Siegel, A., Keller, J., 2016. [Methods for measuring hand hygiene behavior – a methodological examination from a behavioral scientific perspective]. Hyg, Med. 41, D105–D119.
- Drieskens, S., Demarest, S., Bel, S., De Ridder, K., Tafforeau, J., 2018. Correction of selfreported BMI based on objective measurements: a Belgian experience. Arch. Public Health 76, 10.
- Ejemot-Nwadiaro, R.I., Ehiri, J.E., Arikpo, D., Meremikwu, M.M., Critchley, J.A., 2015. Hand washing promotion for preventing diarrhoea. Cochrane Database Syst. Rev. CD004265.
- Freeman, M.C., Stocks, M.E., Cumming, O., Jeandron, A., Higgins, J.P., Wolf, J., Pruss-Ustun, A., Bonjour, S., Hunter, P.R., Fewtrell, L., Curtis, V., 2014. Hygiene and health: systematic review of handwashing practices worldwide and update of health effects. Trop. Med. Int. Health 19, 906–916.
- Gammon, J., Hunt, J., 2019. The neglected element of hand hygiene significance of hand drying, efficiency of different methods and clinical implication: a review. J. Infect. Prev. 20, 66–74.
- Griffin, J.M., Burgess, D., Vernon, S.W., Friedemann-Sanchez, G., Powell, A., van Ryn, M., Halek, K., Noorbaloochi, S., Grill, J., Bloomfield, H., Partin, M., 2009. Are gender differences in colorectal cancer screening rates due to differences in selfreporting? Prev. Med. 49, 436–441.
- Gupta, A.K., Lyons, D.C., Rosen, T., 2015. New and emerging concepts in managing and preventing community-associated methicillin-resistant Staphylococcus aureus infections. Int. J. Dermatol. 54, 1226–1232.
- Haberecht, K., Schuerer, I., Gaertner, B., John, U., Freyer-Adam, J., 2015. The stability of social desirability: a latent change analysis. J. Pers. 83, 404–412.
- Hoffmeyer-Zlotnik, J.H.P., Hanefeld, U., Herter-Eschweiler, R., Mohr, S., 2010. Demographische Standards. Statistisches Bundesamt, Wiesbaden.
- Jenner, E.A., Fletcher, B.C., Watson, P., Jones, F.A., Miller, L., Scott, G.M., 2006. Discrepancy between self-reported and observed hand hygiene behaviour in health care professionals. J. Hosp. Infect. 63, 418–422.
- Jensen, D.A., Danyluk, M.D., Harris, L.J., Schaffner, D.W., 2015. Quantifying the effect of hand wash duration, soap use, ground beef debris, and drying methods on the removal of *Enterobacter* Aerogenes on hands. J. Food Protect. 78, 685–690.
- Kahneman, D., Krueger, A.B., Schkade, D.A., Schwarz, N., Stone, A.A., 2004. A survey method for characterizing daily life experience: the day reconstruction method. Science 306, 1776–1780.
- Lynch, C., Mahida, N., Oppenheim, B., Gray, J., 2020. Washing our hands of the problem. J. Hosp. Infect. 104, 401–403.
- Meilicke, G., Riedmann, K., Biederbick, W., Muller, U., Wierer, T., Bartels, C., 2013. Hygiene perception changes during the influenza A H1N1 pandemic in Germany: incorporating the results of two cross-sectional telephone surveys 2008-2009. BMC Publ. Health 13, 959.
- Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., Eccles, M.P., Cane, J., Wood, C.E., 2013. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Ann. Behav. Med. 46, 81–95.
- Mumma, J.M., Durso, F.T., Casanova, L.M., Erukunuakpor, K., Kraft, C.S., Ray, S.M., Shane, A.L., Walsh, V.L., Shah, P.Y., Zimring, C., DuBose, J., Jacob, J.T., 2019. Variability in the duration and thoroughness of hand hygiene. Clin. Infect. Dis. 69, S221–S223.

considered as a speculative but thought-provoking impulse in terms of possibilities to develop algorithms for correcting self-reported handwashing based on observed compliance. Such an endeavour may borrow from related efforts in which self-reported body mass indices (BMI) are multiplied with correction factors empirically derived by comparison with measured BMI to produce corrected body mass classification (see e. g., Drieskens et al., 2018). Unfortunately, no pertinent data are available for Germany's general population using the day reconstruction or the script-based covert recall method. In any case, self-reported here, may be used in handwashing promotion campaigns to provide more concise feedback on the behaviour of the population, i.e., based not only on frequency, but duration and technique as well. This may sensitize target groups in regard to discrepancies between subjective estimates of their own handwashing habits and the "objective" reality.

e., 1+((84.1-48.7)/48.7)). With all bidden caution, this may be

Finally, the analyses of determinants of self-reported hand hygiene behaviour, i.e., - following recent nomenclature (White et al., 2020) especially characteristics (i.e., socio-demographics) and (as one feature of the social environment) recall of handwashing instructions plates in public restrooms, produced results that were by and large consistent with findings of earlier studies (White et al., 2020). Additionally, it seems fair to say that the associations between socio-demographics and the different handwashing indices, i.e., based on single vs. combined attributes, revealed a number of notable variations (e.g., higher compliance with technical facets of handwashing among men and with indications but not duration and technique among respondents with a migration background). At the same time, they were not dissimilar overall to an extent that would clearly contradict earlier findings. Regarding handwashing instruction plates in public toilets, it may be a significant finding that although these reminders focus on duration and technique of handwashing, women recalling them reported higher compliance regarding frequency. Among men, this notion especially held for regular use of hand disinfectants. Thus, further studies may be worthwhile to examine whether information on specific attributes of handwashing carries over to other attributes or hand hygiene behaviours in educational campaigns or whether our finding merely reflects reverse causation (i.e., that compliance leads to recollection, not vice versa).

5. Conclusions

To conclude, it seems premature to waive self-report survey items aiming to assess population hand hygiene behaviour within a "direct questions on handwashing" paradigm. Partitioning this behavioural domain into different attributes and using indices based on combinations of attributes may be an option to deal with overestimation tendencies in self-reports. Additionally, compliance estimates based on such indices may be used in interventions to provide feedback on behaviour, uncover discrepancies with relevant self-perceptions, and thus promote awareness and motivate better hand hygiene compliance in the population, which becomes of paramount importance in pandemic situations.

Notes

1. This manuscript conforms to the STROBE- (STrengthening the Reporting of OBservational studies in Epidemiology-) Statement for cross-sectional studies (https://www.strobe-statement.org/index.php? id=strobe-home; see Supplementary Material).

2. No third-party funding has been received for the work carried out to prepare the manuscript.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

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Rabie, T., Curtis, V., 2006. Handwashing and risk of respiratory infections: a quantitative systematic review. Trop. Med. Int. Health 11, 258–267.

- Ram, P., 2013. Practical guidance for measuring handwashing behavior: 2013 update, 2 ed. University at Buffalo, The State University of New York, Buffalo, NY.
- Sassenrath, C., Diefenbacher, S., Siegel, A., Keller, J., 2016. A person-oriented approach to hand hygiene behaviour: emotional empathy fosters hand hygiene practice. Psychol. Health 31, 205–227.
- Ward, M.A., Schweizer, M.L., Polgreen, P.M., Gupta, K., Reisinger, H.S., Perencevich, E. N., 2014. Automated and electronically assisted hand hygiene monitoring systems: a systematic review. Am. J. Infect. Control 2, 472–478.
- White, S., Thorseth, A.H., Dreibelbis, R., Curtis, V., 2020. The determinants of handwashing behaviour in domestic settings: an integrative systematic review. Int. J. Hyg. Environ. Health 227, 113512.
- Wolf, J., Hunter, P.R., Freeman, M.C., Cumming, O., Clasen, T., Bartram, J., Higgins, J.P. T., Johnston, R., Medlicott, K., Boisson, S., Prüss-Ustün, A., 2018. Impact of drinking

water, sanitation and handwashing with soap on childhood diarrhoeal disease:

- updated meta-analysis and meta-regression. Trop. Med. Int. Health 23, 508–525. Wolf, J., Johnston, R., Freeman, M.C., Ram, P.K., Slaymaker, T., Laurenz, E., Prüss-Ustün, A., 2019a. Handwashing with soap after potential faecal contact: global,
- regional and country estimates. Int. J. Epidemiol. 48, 1204–1218.
 Wolf, J., Johnston, R., Hunter, P.R., Gordon, B., Medlicott, K., Prüss-Ustün, A., 2019b.
 A Faecal Contamination Index for interpreting heterogeneous diarrhoea impacts of water, sanitation and hygiene interventions and overall, regional and country estimates of community sanitation coverage with a focus on low- and middle-income countries. Int. J. Hyg. Environ. Health 222, 270–282.
- World Health Organization, 2003. Adherence to long-term therapies: evidence for action. World Health Organization, Geneva.
- World Health Organization, 2009. WHO guidelines on hand hygiene in health care: First Global Patient Safety Challenge Clean Care Is Safer Care. World Health Organization, Geneva.