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Blood pressure in Germany 2008–2011

Results of the German Health Interview and Examination Survey for Adults (DEGS1)

Background and purpose

Raised blood pressure is the most frequent and most important risk factor for cardiovascular diseases and kidney disease [1] and thus one of the most important modifiable risk factors for morbidity and mortality in Germany and worldwide [2]. It is estimated that high blood pressure leads to 9.4 million deaths per year worldwide [3] and is responsible for 54% of all strokes and 47% of ischemic heart disease [4]. The potential for prevention of high blood pressure is large, since lifestyle-related factors such as lack of physical activity, unhealthy diet, overweight and stress all contribute considerably to the development of high blood pressure [5] and since high blood pressure can be successfully lowered with changes in lifestyle and with medication. Small population-wide changes in blood pressure can have large overall effects: a population-wide reduction in systolic blood pressure (SBP) of 5 mmHg can lead to a population-wide reduction in stroke mortality of 14%, in coronary heart disease of 9% and in overall mortality of 7% [6, 7].

According to current guidelines hypertension is defined as blood pressure that persistently reaches or exceeds 140 mmHg systolic or 90 mmHg diastolic [8, 9]. However, an increased risk of stroke and coronary heart disease is detectable already at lower levels of 115 mmHg SBP and 75 mmHg diastolic blood pressure (DBP) and this risk increases steadily with rising blood pressure [1]. Therefore, at the population level, hypertension is just the tip of the iceberg. In fact, in addition to the prevalence of hypertension, the prevalence of normal (but no longer optimal) blood pressure and high-normal blood pressure (classified together as prehypertension in US guidelines) are also relevant. Although individual risk associated with prehypertension is lower than risk associated with hypertension, the prevalence of prehypertension is so high within the population that it accounts for approximately half of the blood pressure-related burden of disease [4]. In addition, the mean blood pressure of a population is an important indicator of its cardiovascular risk [1].

This report presents nationwide data on the distribution of blood pressure among 18- to 79-year-old adults in Germany from the German Health Interview and Examination Survey for Adults ("Studie zur Gesundheit Erwachsener in Deutschland", DEGS), first wave, DEGS1 2008–2011, and thereby updates previous data from the German National Health Interview and Examination Survey 1998 (GNHIES98).

Methods

The German Health Interview and Examination Survey for Adults (DEGS) is part of the health monitoring system at the Robert Koch Institute (RKI). The concept and design of DEGS are described in detail elsewhere [10, 11, 12, 13, 14]. The first wave (DEGS1) was conducted from 2008–2011 and comprised interviews, examinations and tests [15, 16]. The target population comprises the residents of Germany aged 18–79 years. DEGS1 has a mixed design, which permits both cross-sectional and longitudinal analyses. For this purpose, a random sample from local population registries was drawn to complete the participants from the German National Health Interview and Examination Survey 1998 (GNHIES98), who re-participated. A total of 8,152 persons participated, including 4,193 first-time participants (response rate 42%) and 3,959 revisiting participants of GNHIES98 (response rate 62%). There were 7,238 persons who attended one of the 180 examination centres, and 914 who were interviewed only. The net sample [11] permits representative cross-sectional analyses and trend statements for the age group from 18–79 in comparison with GNHIES98 (n=7,988, including 7,116 seen in examination centres). Longitudinal analyses can be performed with the data from revisiting participants. The cross-sectional and longitudinal analyses are conducted using a weighting factor, which corrects deviations in the sample from the population structure (as of 31 Dec 2010) with respect to age, sex, region and nationality as well as type of municipality and education [11]. A special weighting factor was generated for the examination part of the study. The calculation of the weighting for for-

Tab. 1 Mean systolic and diastolic blood pressure in men and women in mmHg (SD), DEGS1, $n_{unweighted}$=7,096

Age group	18–29	30–39	40–49	50–59	60–69	70–79	Total
Sex							
Women							
SBP	113.33 (0.51)	113.45 (0.74)	117.90 (0.65)	123.67 (0.76)	127.71 (0.83)	131.46 (0.97)	120.77 (0.35)
DBP	66.33 (0.36)	69.72 (0.50)	72.23 (0.42)	74.50 (0.44)	73.03 (0.45)	71.30 (0.47)	71.19 (0.20)
Men							
SBP	124.78 (0.49)	124.62 (0.63)	127.08 (0.67)	129.81 (0.68)	129.00 (0.86)	130.27 (0.97)	127.40 (0.33)
DBP	70.04 (0.37)	73.75 (0.47)	77.96 (0.49)	79.70 (0.44)	76.05 (0.51)	73.29 (0.65)	75.31 (0.24)
Total							
SBP	119.17 (0.38)	119.15 (0.56)	122.58 (0.52)	126.74 (0.54)	128.34 (0.64)	130.93 (0.74)	124.07 (0.27)
DBP	68.23 (0.25)	71.77 (0.36)	75.16 (0.36)	77.10 (0.34)	74.50 (0.37)	72.20 (0.41)	73.24 (0.18)

SBP systolic blood pressure, *DBP* diastolic blood pressure.

mer participants in GNHIES98 also accounted for the reparticipation probability of GNHIES98 participants, based on a logistic regression model. A non-response analysis and comparison of selected indicators from census statistics indicate a high level of representativity of the net sample for the residential population aged 18–79 in Germany [11]. In order to take into account both the weighting and the correlation of participants within one municipality, confidence intervals were determined using SPSS 20 procedures for complex samples.

Social status was determined using an index which includes information on school education and vocational training, occupational status and net household income (weighted by household needs) permitting classification into low, middle and high status groups [17].

Systolic, diastolic and mean arterial pressures as well as pulse rate were determined using automatic blood pressure monitors (Datascope Accutorr Plus), which were also used in the German Health Interview and Examination Survey for Children and Adolescents (KiGGS). These devices use the oscillometric technique and not the auscultatory method used in GNHIES98. When measuring blood pressure with an oscillometric device—as in auscultatory measurement—a pressure cuff on the upper arm is inflated to a level above the expected systolic pressure. With the auscultatory method the systolic and diastolic blood pressures are determined by well trained examiners by slowly releasing the pressure and listening (auscultation) with a stethoscope for the first and last sounds (Korotkoff sounds) in the brachial artery. With the oscillometric method on the other hand, oscillations transmitted from the vascular wall to the pressure cuff are evaluated automatically by the device and the blood pressure readings are displayed. The device used in DEGS1 meets the criteria of the Association for the Advancement of Medical Instrumentation and the British Hypertension Society with respect to its agreement with the gold standard of auscultatory measurement using a standard mercury sphygmomanometer [18, 19, 20, 21]. Measurements were made in accordance with a standardised protocol. Participants sat upright on a height-adjustable chair with a backrest, the right forearm was resting on a table at the level of the heart, the elbow was slightly bent, the legs were not crossed and the feet were placed firmly on the floor. To determine the cuff size the circumference of the upper arm was measured half way between the acromion and the olecranon (highest point of the shoulder blade to the tip of the elbow). Three cuffs were used according to the following rule: a small cuff (cuff bladder 10.5×23.9 cm) for an upper arm circumference of 21–27.9 cm, a medium cuff (cuff bladder 13.5×30.7 cm) for an upper arm circumference of 28–35.9 cm, and a large cuff (cuff bladder 17×38.6 cm) for an upper arm circumference of 36–46 cm. A mark on the cuff was used to ensure that the cuff was correctly positioned over the brachial artery. Following a 5-minute rest three measurements were taken at 3-minute intervals. There was no speaking while measurements were taken. Finally the participant was informed of any findings and given the results. Observance of the standardised examination protocol was subject to regular quality control. Analyses of SBP and DBP are based on the mean of the second and third blood pressure measurements.

Participants were asked as part of the medical interview whether they had ever been told by a doctor that they have high or elevated blood pressure. As part of the medication interview it was recorded whether participants were taking antihypertensive medication. The interview included all medication taken over the previous 7 days. Drugs were coded in accordance with the World Health Organization's (WHO) Anatomic Therapeutic Chemical Classification System (ATC code). Medications were recorded as being antihypertensive if their primary effect is to lower blood pressure: diuretics (ATC code C03), beta-blockers (C07), calcium channel blockers (C08), ACE inhibitors (C09) and antihypertensive drugs (C02). However, since the indication for taking these drugs may be other than hypertension, the antihypertensive medication was only used for defining hypertension if the participant had known hypertension.

The following definitions were used based on the DEGS blood pressure measurements, information on antihypertensive medication and previous diagnoses:

Hypertension: hypertensive blood pressure in DEGS1 (SBP ≥140 or DBP ≥90 mmHg, using the means of the second and third DEGS1 measurements) or intake of antihypertensive medication in the previous 7 days given that the person had known hypertension.

Known hypertension: hypertension according to the above definition in people who reported that they had been told pre-

viously by a doctor that they have high or elevated blood pressure.

Hypertensive blood pressure with no previous diagnosis of hypertension: hypertensive blood pressure in DEGS1 (SBP ≥140 or DBP ≥90 mmHg, using the mean of the second and third DEGS1 measurements) in participants who denied detection of high or elevated blood pressure by a doctor in the past. This category is internationally customary in epidemiological studies [22, 23], but only partly fulfils the clinical definition of hypertension. It is not designated "undiagnosed hypertension" since measurements were taken on 1 day only, in contrast to the requirements for a clinical diagnosis.

Results

In DEGS1 standardised blood pressure measurements were carried out in 7,096 of the 7,116 18- to 79-year-old participants in the cross-sectional sample. The mean SBP in 18- to 79-year-old men was 127.4 mmHg, while in 18- to 79-year-old women it was 120.8 mmHg (total 124.1 mmHg; **Tab. 1**). The mean DBP in 18- to 79-year-old men was 75.3 mmHg, while in 18- to 79-year-old women it was 71.2 mmHg (total 73.2 mmHg). In almost every decade of life men had higher mean blood pressure than women. This difference was most pronounced for SBP and at younger ages. Among women there was a marked rise in SBP with age. SBP in men and DBP in both men and women, however, first rose with age but then reached a plateau approximately in the sixth decade (SBP in men), and then decreased again slightly (DBP in men and women).

Blood pressure was classified (**Tab. 2**) in accordance with the classification of the European Society of Hypertension, which has also been adopted by the German Hypertension Society ("Deutsche Hochdruckliga e. V."). According to this, 13% of women and 18% of men had hypertensive blood pressure (SBP ≥140 mmHg or DBP ≥90 mmHg), but only 29% of men and 53% of women had optimal blood pressure (SBP <120 mmHg and DBP <80 mmHg). The differences between men and women were most pronounced in the youngest age group of 18–29 year olds: among men 8% had hypertensive blood pressure and only 33% had optimal blood pressure, while among women less than 1% had hypertensive blood pressure and over 76% had optimal blood pressure.

The prevalence of hypertension observed in this analysis, however, relates not only to hypertensive blood pressure on examination, but also includes hypertension controlled by medication. Thus the prevalence of hypertension in the entire sample of 18–79 year olds was 32% and was not substantially different in men and women (women 30%, men 33% with overlapping confidence intervals, **Tab. 3**). A distinct rise with age could

Abstract · Zusammenfassung

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Blood pressure in Germany 2008–2011. Results of the German Health Interview and Examination Survey for Adults (DEGS1)

Abstract

High blood pressure is one of the most important risk factors for cardiovascular diseases and chronic kidney disease. It is a main determinant of morbidity and mortality in Germany. In the German Health Interview and Examination Survey for Adults (DEGS1) the blood pressure of 7,096 adults aged 18–79 years was measured in a standardised way using oscillometric blood pressure devices (Datascope Accutorr Plus). The average of the second and third measurements was used for analysis. The mean systolic blood pressure was 120.8 mmHg in women and 127.4 mmHg in men, while the mean diastolic blood pressure was 71.2 mmHg in women and 75.3 mmHg in men. Blood pressure values were hypertensive (systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg) in 12.7% of women and in 18.1% of men. Hypertension (defined as having hypertensive blood pressure or taking antihypertensive medication in known cases of hypertension) was present in 29.9% of women and 33.3% of men. Almost 75% of the survey's highest age group, 70–79, had hypertension. DEGS1 demonstrates that high blood pressure remains a highly prevalent risk factor in the population at large. The methodology employed in measuring blood pressure has been improved as compared to that of the German National Health Interview and Examination Survey 1998 (GNHIES98) and it will be possible to draw comparisons soon, once a procedure for calibrating the 1998 data has been finalised.

Keywords

Health survey · Blood pressure · Hypertension · Prevalence

Blutdruck in Deutschland 2008–2011. Ergebnisse der Studie zur Gesundheit Erwachsener in Deutschland (DEGS1)

Zusammenfassung

Hoher Blutdruck gehört zu den wichtigsten Risikofaktoren für Herz-Kreislauf-Krankheiten und chronische Niereninsuffizienz. Er ist eine wesentliche Determinante für Morbidität und Mortalität in Deutschland. Im Rahmen der bundesweiten Studie zur Gesundheit Erwachsener in Deutschland DEGS1 wurde bei 7096 Erwachsenen im Alter von 18 bis 79 Jahren der Blutdruck standardisiert mit einem oszillometrischen Blutdruckmessgerät (Datascope Accutorr Plus) gemessen und der Durchschnitt der zweiten und dritten Messung ausgewertet. Der mittlere Blutdruck betrug systolisch bei Frauen 120,8 mmHg, bei Männern 127,4 mmHg, diastolisch bei Frauen 71,2 mmHg, bei Männern 75,3 mmHg. Die Blutdruckwerte waren hyperton (systolischer Blutdruck ≥140 mmHg oder diastolisch ≥90 mmHg) bei 12,7% der Frauen und 18,1% der Männer. Eine Hypertonie (definiert als hypertoner Messwert oder Einnahme antihypertensiver Medikamente bei bekannter Hypertonie) lag bei 29,9% der Frauen und 33,3% der Männer vor. In der höchsten untersuchten Altersgruppe der 70- bis 79-Jährigen hatten fast 75% eine Hypertonie. DEGS1 zeigt, dass Bluthochdruck nach wie vor ein weit verbreiteter Risikofaktor in der Bevölkerung ist. Die Methodik der Blutdruckmessung ist im Vergleich zu der im Bundes-Gesundheitssurvey 1998 verbessert worden, sodass Vergleiche erst in Kürze, nach Fertigstellung eines Kalibrierungsverfahrens der Daten von 1998, möglich sein werden.

Schlüsselwörter

Gesundheitssurvey · Blutdruck · Hypertonie · Bluthochdruck · Prävalenz

Tab. 2 Blood pressure in adults in Germany (prevalence and 95% CI), DEGS1, $n_{unweighted}$=7,096

Age group	18–29	30–39	40–49	50–59	60–69	70–79	18–79
Men							
Optimal	32.6 (28.5–36.9)	34.7 (29.3–40.6)	29.1 (24.8–33.9)	21.6 (18.2–25.4)	27.7 (23.2–32.7)	27.1 (22.4–32.3)	28.8 (26.8–31.0)
Normal	36.6 (32.0–41.5)	34.4 (29.1–40.2)	29.5 (25.0–34.4)	26.9 (23.1–31.0)	25.6 (21.7–29.8)	22.5 (18.0–27.7)	29.8 (27.8–31.8)
High normal	22.7 (18.6–27.5)	23.7 (18.8–29.4)	21.5 (17.7–25.9)	28.2 (23.7–33.0)	22.9 (18.9–27.6)	19.8 (16.1–24.1)	23.3 (21.5–25.2)
Hypertensive	8.1 (5.6–11.5)	7.2 (4.6–11.0)	19.9 (16.1–24.3)	23.4 (19.8–27.4)	23.8 (19.4–28.8)	30.7 (25.6–36.3)	18.1 (16.2–20.2)
Stage 1	7.9 (5.5–11.4)	7.2 (4.6–11.0)	17.5 (13.8–21.9)	19.1 (15.9–22.9)	19.4 (15.6–23.9)	27.0 (22.1–32.6)	15.8 (14.0–17.7)
Stage 2 or 3	0.2 (0.0–0.7)	0.0 (0.0–0.0)	2.4 (1.4–4.1)	4.3 (2.6–6.9)	4.4 (2.9–6.6)	3.6 (2.1–6.3)	2.4 (1.8–3.0)
Women							
Optimal	75.9 (71.3–80.0)	74.3 (68.9–79.0)	61.0 (56.1–65.7)	42.8 (37.7–48.0)	32.9 (27.9–38.4)	22.9 (18.5–28.0)	53.0 (50.7–55.2)
Normal	19.2 (15.4–23.5)	17.1 (13.3–21.8)	21.1 (17.5–25.2)	23.1 (19.4–27.2)	22.8 (18.6–27.6)	23.9 (19.9–28.3)	21.1 (19.6–22.8)
High normal	4.0 (2.4–6.5)	6.3 (4.2–9.5)	9.7 (7.4–12.5)	18.8 (15.1–23.2)	22.6 (18.6–27.1)	20.5 (16.5–25.1)	13.2 (11.9–14.6)
Hypertensive	0.9 (0.4–2.1)	2.3 (1.0–5.2)	8.2 (6.1–11.0)	15.3 (12.5–18.7)	21.7 (17.8–26.3)	32.8 (28.1–37.7)	12.7 (11.3–14.3)
Stage 1	0.8 (0.3–1.9)	2.0 (0.9–4.5)	6.9 (5.0–9.6)	13.6 (10.9–16.9)	18.7 (15.2–22.9)	27.4 (23.2–32.1)	10.9 (9.5–12.3)
Stage 2 or 3	0.1 (0.0–1.0)	0.3 (0.0–2.1)	1.3 (0.6–2.8)	1.7 (0.9–3.2)	3.0 (1.5–6.0)	5.4 (3.4–8.4)	1.8 (1.3–2.5)
Total							
Optimal	53.8 (50.4–57.2)	54.1 (49.7–58.5)	44.7 (41.3–48.2)	32.2 (29.0–35.6)	30.4 (26.8–34.2)	24.8 (21.4–28.6)	41.0 (39.3–42.7)
Normal	28.1 (24.9–31.4)	25.9 (22.5–29.7)	25.4 (22.4–28.5)	25.0 (22.2–28.0)	24.1 (21.3–27.3)	23.2 (20.1–26.7)	25.4 (24.2–26.7)
High normal	13.6 (11.3–16.2)	15.2 (12.3–18.6)	15.7 (13.4–18.3)	23.5 (20.6–26.7)	22.8 (19.8–26.0)	20.2 (17.4–23.2)	18.2 (17.1–19.4)
Hypertensive	4.6 (3.3–6.4)	4.8 (3.3–7.0)	14.2 (11.8–17.0)	19.4 (16.8–22.2)	22.7 (19.6–26.2)	31.8 (28.2–35.7)	15.4 (14.1–16.8)
Stage 1	4.4 (3.1–6.2)	4.6 (3.2–6.7)	12.3 (10.0–15.1)	16.4 (14.1–18.9)	19.1 (16.4–22.0)	27.2 (23.8–31.0)	13.3 (12.1–14.6)
Stage 2 or 3	0.2 (0.0–0.5)	0.1 (0.0–1.1)	1.9 (1.2–2.9)	3.0 (2.0–4.4)	3.7 (2.5–5.4)	4.6 (3.2–6.5)	2.1 (1.7–2.6)

Blood pressure classification in mmHg: ***optimal*** systolic blood pressure SBP <120 and diastolic blood pressure DBP <80, ***normal*** SBP 120–129 or DBP 80–84, ***high normal*** SBP 130–139 or DBP 85–89, ***Stage 1 hypertensive*** SBP 140–159 or DBP 90–99, ***Stage 2 or 3 hypertensive*** SBP ≥160 or DBP ≥100. When a patient's SBP and DBP fall in different categories, the higher category is used.

Tab. 3 Hypertension by age, sex and social status (prevalence and 95% CI), DEGS1, $n_{unweighted}$=7,096

Age group	18–29	30–39	40–49	50–59	60–69	70–79	Total
Sex							
Women	1.3 (0.7–2.6)	4.8 (2.8–8.2)	17.2 (14.2–20.7)	34.6 (30.5–38.4)	60.7 (55.7–65.5)	74.7 (70.2–78.8)	29.9 (28.1–31.9)
Men	8.4 (5.9–11.8)	11.4 (8.1–15.8)	26.2 (22.1–30.7)	41.7 (37.3–46.2)	58.8 (53.5–63.2)	73.6 (68.5–78.1)	33.3 (31.1–35.6)
Total	4.9 (3.6–6.7)	8.2 (6.2–10.8)	21.8 (19.0–24.8)	38.1 (35.0–41.4)	59.8 (56.1–63.3)	74.2 (70.6–77.5)	31.6 (30.1–33.2)
Social status							
Women							
Low	0.8 (0.2–3.6)	5.1 (1.2–19.0)	24.8 (15.6–36.9)	44.1 (33.0–55.9)	70.9 (59.3–80.3)	67.3 (57.5–75.8)	37.1 (32.8–41.6)
Middle	1.1 (0.4–2.8)	6.1 (3.3–11.0)	17.6 (13.9–22.0)	35.1 (30.0–40.5)	60.8 (54.3–66.9)	80.3 (75.2–84.6)	31.0 (28.7–33.5)
High	3.3 (1.0–10.2)	2.1 (0.7–6.0)	11.2 (6.8–18.0)	26.5 (18.3–36.9)	44.5 (34.2–55.3)	62.4 (48.9–74.1)	18.8 (15.3–22.7)
Men							
Low	9.0 (3.7–20.7)	14.2 (6.3–29.1)	23.0 (15.0–33.7)	36.0 (25.7–47.7)	52.3 (39.7–64.5)	76.0 (62.8–85.5)	32.3 (27.1–37.9)
Middle	8.7 (6.0–12.4)	11.7 (7.5–17.9)	25.6 (20.4–31.6)	42.5 (36.6–48.7)	59.6 (52.3–66.5)	75.9 (69.7–81.2)	33.4 (30.8–36.1)
High	6.7 (2.2–18.2)	10.2 (5.1–19.1)	30.3 (22.9–38.8)	43.5 (34.9–52.6)	61.4 (53.3–68.4)	64.2 (52.2–74.6)	34.6 (31.0–38.3)
Total							
Low	4.8 (2.1–10.9)	10.2 (5.0–19.8)	23.8 (17.6–31.5)	39.8 (32.0–48.2)	62.3 (53.5–70.4)	70.5 (62.2–77.6)	34.7 (31.3–38.4)
Middle	5.0 (3.6–7.0)	8.9 (6.2–12.5)	21.4 (18.0–25.3)	38.7 (34.9–42.7)	60.3 (55.4–64.9)	78.4 (74.5–81.8)	32.2 (30.3–34.1)
High	5.0 (2.2–11.0)	6.3 (3.5–11.0)	22.0 (17.1–27.8)	34.9 (27.9–42.6)	55.2 (48.5–61.8)	63.5 (54.8–71.5)	27.5 (24.9–30.3)

Hypertension SBP ≥140 or DBP ≥90 mmHg (mean of second and third DEGS1 measurements) or antihypertensive medication within last 7 days given that the person had known hypertension, ***95% CI*** 95% confidence interval.

be observed in 18–50 year olds, with the prevalence of hypertension almost doubling every 10 years and doubling again over the next 20 years, such that among 70–79 year olds the prevalence was over 70%. Prevalence-related differences in social status were evident among women, as women with high social status had a prevalence of hypertension only half that of women with low social status (**Tab. 3**). Among men the prevalence of hypertension did not vary with social status.

Hypertension was subdivided into known hypertension and hypertensive blood pressure in DEGS1 without reported detection of high or elevated blood pressure by a doctor in the past (**Tab. 4**). Overall, hypertension was al-

Tab. 4 Known hypertension and hypertensive blood pressure (BP) ***with no previous diagnosis of hypertension*** (point prevalence and 95% CI), DEGS1, $n_{unweighted}$=7,096

Age group	18-29	30-39	40-49	50-59	60-69	70-79	Total
Women							
Known hypertension	0.9 (0.4–1.9)	3.3 (1.7–6.4)	13.6 (10.9–16.8)	28.0 (24.5–31.9)	54.9 (50.1–59.7)	67.8 (62.8–72.5)	25.9 (24.2–27.6)
Hypertensive BP	0.4 (0.1–1.7)	1.5 (0.6–3.8)	3.5 (2.1–5.7)	6.3 (4.3–9.2)	5.7 (3.7–8.5)	6.8 (4.7–10.0)	4.0 (3.2–4.9)
Men							
Known hypertension	1.9 (1.0–3.7)	7.5 (4.8–11.5)	17.5 (14.0–21.6)	32.7 (28.5–37.2)	51.8 (46.6–56.9)	64.9 (59.2–70.2)	26.0 (24.6–27.3)
Hypertensive BP	6.2 (4.0–9.5)	3.5 (1.8–6.7)	8.5 (6.0–12.0)	9.0 (6.8–11.7)	7.0 (4.8–9.9)	8.5 (5.5–13.0)	7.2 (6.1–8.4)
Total							
Known hypertension	1.4 (0.8–2.3)	5.4 (3.8–7.8)	15.6 (13.3–18.2)	30.4 (27.6–33.3)	53.4 (49.8–57.0)	66.5 (62.8–70.0)	25.9 (24.6–27.3)
Hypertensive BP	3.4 (2.2–5.1)	2.5 (1.5–4.3)	6.1 (4.6–8.0)	7.7 (6.1–9.6)	6.3 (4.8–8.2)	7.6 (5.8–10.0)	5.6 (4.9–6.3)

Known hypertension hypertensive blood pressure (*BP*) (SBP ≥140 or DBP ≥90 mmHg) or antihypertensive medication in the past 7 days, in participants who reported that they had been told previously by a doctor that they have high or elevated blood pressure. *Hypertensive BP* hypertensive BP in DEGS1 (SBP ≥140 or DBP ≥90 mmHg, using the mean of the second and third DEGS1 measurements) in participants who denied detection of high or elevated blood pressure by a doctor in the past.

ready known to be present in the vast majority of instances: among all age groups (18–79) on average one in four men and one in four women had known hypertension (26%, **Tab. 4**). In addition, 4% of all women and 7% of all men had hypertensive blood pressure in DEGS1 and thus may have undiagnosed hypertension. The proportion of hypertensive blood pressure that first came to light in DEGS compared to all instances of hypertension according to the stated definition was 22% among men and 13% among women, although there were marked age-related differences: in the younger age groups and within them, among men in particular, the proportion was higher and reached up to 76% among 18- to 29-year-old men. Both known hypertension and hypertensive blood pressure without previous detection of high or elevated blood pressure were more prevalent in women with low social status compared to women with middle or high social status. Such social status differences were not found in men.

Discussion

DEGS1 provides information on the distribution of blood pressure in Germany and thus on the distribution of one of the most important preventable risk factors both for cardiovascular diseases and for overall mortality. Cardiovascular diseases are still ranked highest in the mortality statistics in Germany [24]. However, the significant drop in stroke mortality and total cardiovascular mortality over the last 20 years [25] suggests there may have been positive developments in the most important modifiable risk factors, particularly blood pressure.

DEGS1 shows that hypertension affects approximately 20 million adults in Germany and is therefore still a widely prevalent risk factor in the population. One in three adults in Germany has hypertension (30% of women and 33% of men). The prevalence in young adults (18–29) is just under 5% but among 70–79 year olds it reaches almost 75%. This hypertension prevalence data also includes one fifth undiagnosed hypertension as suggested by the DEGS1 measurements (18% overall, 13% of women, 22% of men). A limitation of this finding is that undiagnosed hypertension can only be suspected from DEGS1 data, because although three blood pressure measurements were made under standardised conditions in DEGS1 they were on one study day, which is not sufficient for a clinical diagnosis of hypertension. Conversely, these figures yield an estimated level of hypertension awareness of over 80% in Germany, which is high when compared internationally [23, 26], but which is still unsatisfactory, particularly among young men (less than a quarter of men under 30 are aware of having hypertension). Despite certain differences in definition, the DEGS1 prevalence of known hypertension is consistent with results from the telephone survey GEDA 2010 (German Health Update, Gesundheit in Deutschland aktuell 2010) conducted by the Robert Koch Institute [27].

However, the actual level of blood pressure is more important than the diagnosis of hypertension. Approximately half of the participants with hypertension were receiving treatment to control it, i.e. they were taking antihypertensive medication and had blood pressure readings below the hypertension threshold of 140/90 mmHg. Thus at 15% (men 18%, women 13%), the population prevalence of adults with hypertensive blood pressure was only about half as high as the prevalence of hypertension. A detailed analysis of the DEGS1 data on the levels of awareness, treatment and control of hypertension in Germany will be presented in another publication. Only just over 40% of adults had optimal blood pressure, while 44% were at levels which are not yet hypertensive, but which are not optimal and which are associated with an increased risk of cardiovascular disease. Here too there were pronounced differences between men and women, with higher proportions of non-optimal blood pressure values among men than among women in almost all age groups. The gender-related differences even out with increasing age and among 70- to 79-year-old women the prevalence of hypertension was even higher than among men of the same age.

Overall there is still a high potential for prevention. Estimates have shown that a combination of personal and non-personal health care interventions (e.g. hypertension treatment and patient education, programmes for reducing salt in food products, health education through

the media) is cost effective and could lower the global incidence of cardiovascular diseases by as much as 50% [28].

While measuring blood pressure is one of the most common and simple examinations in medicine, epidemiological data that permit a valid assessment of the blood pressure distribution in a population are rare and costly. In clinical practice blood pressure is evaluated according to measurements made on several days or according to 24-h blood pressure measurements and differences in blood pressure of only a few mmHg are of limited significance. In epidemiological studies, however, which deal with whole populations, the effects of a few mmHg accumulate and if they are population-wide they lead to large changes in cardiovascular morbidity and mortality. The prevalence of hypertension can also change to a surprising degree, as many people have blood pressure levels that are only marginally above or below the hypertension threshold. Thus in epidemiological studies great efforts are made to standardise and optimise measurements to avoid systematic measurement errors of even just a few mmHg.

This report presents up-to-date information on blood pressure in Germany from 2008–2011 based on DEGS1 data. The blood pressure measurement methodology used in DEGS1 has been improved compared to that used in GNHIES98, such that comparisons will be possible soon, once a procedure for calibrating the GNHIES98 data has been developed. The changes relate to the switch from the auscultatory method to the oscillometric method of measurement to avoid examiner bias and also relate to improvements in the allocation of pressure cuffs in relation to upper arm circumference. The oscillometric blood pressure device used in DEGS1 was selected based on published validation studies that show a high degree of agreement with the gold standard sphygmomanometer used in GNHIES98 [18, 19, 20].

Along with the change of blood pressure measurement device between GNHIES98 and DEGS1 there was also a change in the cuff bladder sizes offered by manufacturers. This is the consequence of a complex discussion that has gone on for several decades about optimal bladder size and its relation to arm circumference [29]. Since undercuffing (bladder too small) leads to overestimation of blood pressure and overcuffing (bladder too large) to underestimation of blood pressure different pressure cuffs should be available not only for children but also for adults [30]. This has not become established in clinical practice yet. In epidemiological studies however, it is standard practice to have at least three cuffs for adults, although there is still no international consensus as to the optimal relationship between bladder size and upper arm circumference [31, 32]. The measurement protocol used in GNHIES98 including the three cuff sizes was based on the WHO MONICA protocol, which in its original form at the beginning of the MONICA Project in the early 1980s was a reference for highly standardised and valid blood pressure measurement [33]. However, while the GNHIES98 cuff bladder dimensions and the instructions to use them for specific ranges of upper arm circumferences are still formally compatible with European (and in particular with British) guidelines on blood pressure measurement [34], there is now convincing evidence that blood pressure measurement is more valid with the cuffs used in DEGS and that cuff-related blood pressure differences can, at least in epidemiological studies, reach a relevant order of magnitude [35, 36, 37, 38, 39]. Before comparing the data from GNHIES98 and DEGS, the changes in measurement methods (device and cuff changes) were evaluated in a pilot study. This study confirmed the need to calibrate the GNHIES98 data to permit comparison with DEGS1. A calibration procedure is therefore currently being developed on the basis of comprehensive comparative measurements, so that an analysis of temporal trends will soon be possible.

Overall the DEGS1 results confirm the ongoing public health relevance of high blood pressure in Germany. According to a new WHO report, high blood pressure became the greatest health risk worldwide in 2010 [3]. High blood pressure is still highly prevalent in Germany and there is still a large potential for prevention, not only through pharmacologic treatment but through a population-wide shift towards a healthier lifestyle and a health-promoting living environment.

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References

1. Lewington S, Clarke R, Qizilbash N et al (2002) Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet 360:1903–1913
2. Ezzati M, Lopez AD, Rodgers A et al (2002) Selected major risk factors and global and regional burden of disease. Lancet 360:1347–1360
3. Lim SS, Vos T, Flaxmann AD et al (2012) A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 380:2224–2260
4. Lawes CM, Vander Hoorn S, Rodgers A (2008) Global burden of blood-pressure-related disease, 2001. Lancet 371:1513–1518
5. Stamler J, Stamler R, Neaton JD et al (1999) Low risk-factor profile and long-term cardiovascular and noncardiovascular mortality and life expectancy: findings for 5 large cohorts of young adult and middle-aged men and women. JAMA 282:2012–2018
6. Stamler R (1991) Implications of the INTERSALT study. Hypertension 17:I16–20
7. Whelton PK, He J, Appel LJ et al (2002) Primary prevention of hypertension: clinical and public health advisory from The National High Blood Pressure Education Program. JAMA 288:1882–1888
8. Chobanian AV, Bakris GL, Black HR et al (2003) The seventh report of the Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report. JAMA 289:2560–2572
9. Mancia G, De Backer G, Dominiczak A et al (2007) 2007 Guidelines for the management of arterial hypertension: the task force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC). Eur Heart J 28:1462–1536

10. Gößwald A, Lange M, Kamtsiuris P, Kurth BM (2012) DEGS: German health interview and examination survey for adults. A nationwide cross-sectional and longitudinal study within the framework of health monitoring conducted by the Robert Koch-Institute. Bundesgesundheitsbl Gesundheitsforsch Gesundheitsschutz 55:775–780
11. Kamtsiuris P, Lange M, Hoffmann R et al (2013) The first wave of the German health interview and examination survey for adults (DEGS1). Sampling design, response, sample weights, and representativeness. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 56:620–630
12. Kurth BM (2012) Das RKI-Gesundheitsmonitoring—was es enthält und wie es genutzt werden kann. Public Health Forum 20(76):4.e1–4.e3
13. Kurth BM, Lange C, Kamtsiuris P, Hölling H (2009) Health monitoring at the Robert Koch-Institute. Status and perspectives. Bundesgesundheitsbl Gesundheitsforsch Gesundheitsschutz 52:557–570
14. Scheidt-Nave C, Kamtsiuris P, Goesswald A et al (2012) German health interview and examination survey for adults (DEGS)—design, objectives and implementation of the first data collection wave. BMC Public Health 12:730
15. Gößwald A, Lange M, Dölle R, Hölling H (2013) The first wave of the German health interview and examination survey for adults (DEGS1). Participant recruitment, fieldwork, and quality management. Bundesgesundheitsbl Gesundheitsforsch Gesundheitsschutz 56:611–619
16. Robert Koch-Institut (Ed) (2009) DEGS: Studie zur Gesundheit Erwachsener in Deutschland – Projektbeschreibung. Beiträge zur Gesundheitsberichterstattung des Bundes. RKI, Berlin
17. Lampert T, Kroll L, Müters S, Stolzenberg H (2013) Measurement of socioeconomic status in the German health interview and examination survey for adults (DEGSS1). Bundesgesundheitsbl Gesundheitsforsch Gesundheitsschutz 56:631–636
18. Anwar YA, Tendler BE, McCabe EJ et al (1997) Evaluation of the Datascope Accutorr Plus according to the recommendations of the association for the advancement of medical instrumentation. Blood Press Monit 2:105–110
19. Wong SN, Tz Sung RY, Leung LC (2006) Validation of three oscillometric blood pressure devices against auscultatory mercury sphygmomanometer in children. Blood Press Monit 11:281–291
20. White WB, Herbst T, Thavarajah S, Giacco S (2003) Clinical evaluation of the Trimline blood pressure cuffs with the Accutorr Plus Monitor. Blood Press Monit 8:137–140
21. O'Brien E, Waeber B, Parati G et al (2001) Blood pressure measuring devices: recommendations of the European Society of Hypertension. BMJ 322:531–536
22. Antikainen RL, Moltchanov VA, Chukwuma C Sr et al (2006) Trends in the prevalence, awareness, treatment and control of hypertension: the WHO MONICA Project. Eur J Cardiovasc Prev Rehabil 13:13–29
23. Guo F, He D, Zhang W, Walton RG (2012) Trends in prevalence, awareness, management, and control of hypertension among United States adults, 1999–2010. J Am Coll Cardiol 60:599–606
24. Statistisches Bundesamt (2012) Gesundheit. Todesursachen in Deutschland 2010. Fachserie 12, Reihe 4
25. Gaber E, Wildener M (2011) Sterblichkeit, Todesursachen und regionale Unterschiede Berlin. Robert Koch-Institut, Gesundheitsberichterstattung des Bundes, Heft 52
26. Kastarinen MJ, Antikainen RL, Laatikainen TK et al (2006) Trends in hypertension care in eastern and south-western Finland during 1982–2002. J Hypertens 24:829–836
27. Robert Koch-Institut (RKI) (2012) Daten und Fakten: Ergebnisse der Studie "Gesundheit in Deutschland aktuell 2010"
28. Murray CJ, Lauer JA, Hutubessy RC et al (2003) Effectiveness and costs of interventions to lower systolic blood pressure and cholesterol: a global and regional analysis on reduction of cardiovascular-disease risk. Lancet 361:717–725
29. O'Brien E (1996) Review: a century of confusion; which bladder for accurate blood pressure measurement? J Hum Hypertens 10:565–572
30. Appel LJ, Miller ER IIIrd, Charleston J (2011) Improving the measurement of blood pressure: is it time for regulated standards? Ann Intern Med 154:838–840
31. O'Brien E, Asmar R, Beilin L et al (2005) Practice guidelines of the European Society of Hypertension for clinic, ambulatory and self blood pressure measurement. J Hypertens 23:697–701
32. Pickering TG, Hall JE, Appel LJ et al (2005) Recommendations for blood pressure measurement in humans and experimental animals: part 1: blood pressure measurement in humans: a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. Hypertension 45:142–161
33. World Health Organization (1997) MONICA Manual, Part II: Population Survey. Section 1: Population Survey Data Component. 4.2. Blood pressure and arm circumference measurement
34. Parati G, Stergiou GS, Asmar R et al (2008) European Society of Hypertension guidelines for blood pressure monitoring at home: a summary report of the Second International Consensus Conference on Home Blood Pressure Monitoring. J Hypertens 26:1505–1526
35. Maxwell MH, Waks AU, Schroth PC et al (1982) Error in blood-pressure measurement due to incorrect cuff size in obese patients. Lancet 2:33–36
36. Marks LA, Groch A (2000) Optimizing cuff width for noninvasive measurement of blood pressure. Blood Press Monit 5:153–158
37. Fonseca-Reyes S, Alba-Garcia JG de, Parra-Carrillo JZ, Paczka-Zapata JA (2003) Effect of standard cuff on blood pressure readings in patients with obese arms. How frequent are arms of a 'large circumference'? Blood Press Monit 8:101–106
38. Croft PR, Cruickshank JK (1990) Blood pressure measurement in adults: large cuffs for all? J Epidemiol Community Health 44:170–173
39. Bovet P, Hungerbuhler P, Quilindo J et al (1994) Systematic difference between blood pressure readings caused by cuff type. Hypertension 24:786–792