



Correlation between religion and hypertension

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Abstract

The objectives of the study were to investigate the relationship between religion and hypertension, as well as the theoretical mechanism through which religion exerts effect on hypertension. A MEDLINE literature search was performed on articles describing religion and hypertension ($N = 543$) excluding unqualified ones such as those without expected information, those neither correcting confounding factors nor matching the comparison groups and those reporting repeated trials. Eight extra articles from references of reviews were added to the included studies. Finally, 79 articles were formerly evaluated. Briefly, there are limited trials on correlation between religion and hypertension and their results are inconsistent. First of all, longitudinal investigations, especially the high-quality ones, are deficient. Secondly, studies evaluating religion as an integral are scarce, although they can assess religions most comprehensively. Third, few studies use several religious measurements that represent distinct dimensions of religion. Moreover, divergence exists among diverse populations, even if they are assessed by the same indicator. In addition, 59% studies are concerned with an unspecified species of religion, and Christianity is studied the most among those with a specific category of religion. Finally, the possible mechanism underlying religion and hypertension is complex, which can partially explain the different results among various populations. Comprehensive evaluation of a specific religion should be encouraged. In addition, for a specific population, the correlation between religion and hypertension should be examined particularly, even if similar investigations in other populations have been conducted. Finally, more evidence focused on the effects of distinct religions/sects is also required.

Keywords Religion · Hypertension · Blood pressure

Introduction

The Webster's dictionary defines religion as a set of beliefs concerning the cause, nature and purpose of the universe, which usually involves devotional and ritual observances, and often contains a moral code for the conduct of human affairs [1]. Religion is designed to facilitate closeness to the transcendent and to foster an understanding of one's relationship and responsibility to others [2]. The transcendent is often mystical or supernatural, involving God, Allah, HaShem, or a Higher Power in Western traditions, as well as Brahman, manifestations of Brahman, Buddha, Dao, or ultimate truth/reality in Eastern traditions [3]. Sizeable majorities claim to be religious worldwide, and the global

average proportion of religious people is 59% according to a recent survey [4].

Religion, medicine and health care have been related in one way or another in all population groups since the beginning of recorded history [2]. With more evidence revealing that religion may exert effect on its believers both physically and psychologically, increasingly more attention has been paid to religion and health [2, 3].

As the most important risk factor for global disease burden [5, 6], hypertension was ranked number 1 among the 25 leading risk factors for global disability-adjusted life-years (DALYs) [7]. As early as the 1960s, research about religion and hypertension began to be reported [8]; subsequently, studies with similar or different conclusions have been successively and constantly published during the following years. Nevertheless, the last review specifically focused on religion and hypertension can be traced back to nearly 30 years ago [9].

Therefore, this review provides a concise and comprehensive summary of investigations on religion and hypertension

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over these years. The correlation of religion and hypertension, as well as the theoretical mechanism through which religion exerts effect on hypertension will be displayed, respectively. Finally, a perspective for future direction will be proposed.

Method

We systematically searched MEDLINE for papers focused on religion and hypertensive/blood pressure (BP). A retrieval strategy [“religion” OR “religious” OR “religiousness” OR “religiosity” OR Buddhism (title/abstract) OR Buddhist (title/abstract) OR monks (title/abstract) OR nuns (title/abstract) OR Christianity (title/abstract) OR Christianism (title/abstract) OR Christian (title/abstract) OR clergy (title/abstract) OR priest (title/abstract) OR Islam (title/abstract) OR Islamic (title/abstract)] AND (“blood pressure” OR “hypertension” OR “hypertensive”) was used to search relevant articles in PubMed, and 543 articles were displayed. The target papers are those dealing with the role of religion in the hypertensive prevalence or hypertensive incidence or blood pressure.

It is worth mentioning that religion in this review is different from spirituality, since the latter is considered to be free of rules, regulations and responsibilities that are associated with a religion [3]. Therefore, the articles about spirituality or about the combined effect of spirituality and religion are excluded. In addition, stress relaxation not exclusively comprising religious activity should not be included. Moreover, yoga, meditation or other relaxation exercises without religious framework is also distinct from religion. Therefore, 394 papers that contain no expected data or are confounded by above factors were excluded. From the contemporarily included 149 papers, 24 papers about short religious activities such as Ramadan, austerities or Camino de Santiago were excluded. Moreover, 6 qualitative studies, 2 papers not in English or Chinese, and 28 articles about interventional program hosted in religious institutes were also excluded. From the reference list of 18 included reviews/editorial comment, 8 extra original articles were supplemented. Therefore, 79 original articles and 18 reviews were included finally (Fig. 1).

The Newcastle–Ottawa Quality Assessment Scale (NOS) is used to assess the quality of case–control and cohort studies, while the Agency for Healthcare Research and Quality (AHRQ) methodology checklist is used to evaluate cross-sectional studies. The quality of randomized controlled trials was measured by the Cochrane Collaboration’s tool [10], and the Methodological Index for Non-Randomized Studies (MINORS) was used to appraise non-randomized interventional trials [11]. Cross-sectional trials with AHRQ score of 8–11 are defined as high quality. Similarly, longitudinal

trials with NOS score of 7–9 and non-randomized controlled trial with MINORS score of 16–24 (no control group) or 11–16 (with control group) are considered to be of high quality. Finally, if more than half of the items are ranked as low risk in a randomized controlled study, it is defined as a high-quality article.

Findings

From these included papers, the association of religion and hypertension and the underlying mechanisms are elaborated below.

Correlation of religion and hypertension/blood pressure

In these papers dealing with correlation between religion and hypertension/blood pressure, there are 28 cross-sectional articles that neither correct confounding factors nor match the comparison groups. In the rest, there are eight articles reporting the same trials that have already been reported by others [12–19]. After exclusion of the above two categories of articles, 43 trials were left.

In these 43 trials, the comparisons between different religious/sects are quite few [18, 20–22]. In the remaining 39, as high as 23 (59.0%) are assigned to an unspecified specie of religion instead of a specific religious type. Meanwhile, in those with specific category of religion, 9 (23.1%) belong to Christian, 4 to Buddhism (10.3%) and 1 to Jewish (2.6%), Catholic (2.6%) and Islam (2.6%), respectively. Under these conditions, there is not enough evidence to find difference in the effects of various religions/sects. Since almost all the religions except cults encourage people to cherish health and life, they have a common influence on hypertension. Therefore, it is rational to consider all the included trials as uniformly investigating religion and hypertension, no matter what the particular religions/sects are.

The measurement of religion is heterogeneous. Generally, the dependent variables can be divided into two: those representing religion as an integral, such as being full-time religious staff (clergies, monks, nuns, etc.); ordinary residents, being involved in religion or not at all. The latter ones describe specific aspects of religion, for example, religious behavior (e.g., religious attendance frequency, private meditation, etc.), religious attitudes (e.g., subjective religiosity), etc. Each variable reflects just one dimension of a religion, and its capacity to represent the religious core may be different from the others. As a result, trials assessing two or more religion variables in one population simultaneously have demonstrated inconsistent correlations of various variables with hypertension [23–26]. Above all, in this section, the trials are uniformly considered to evaluate religion and

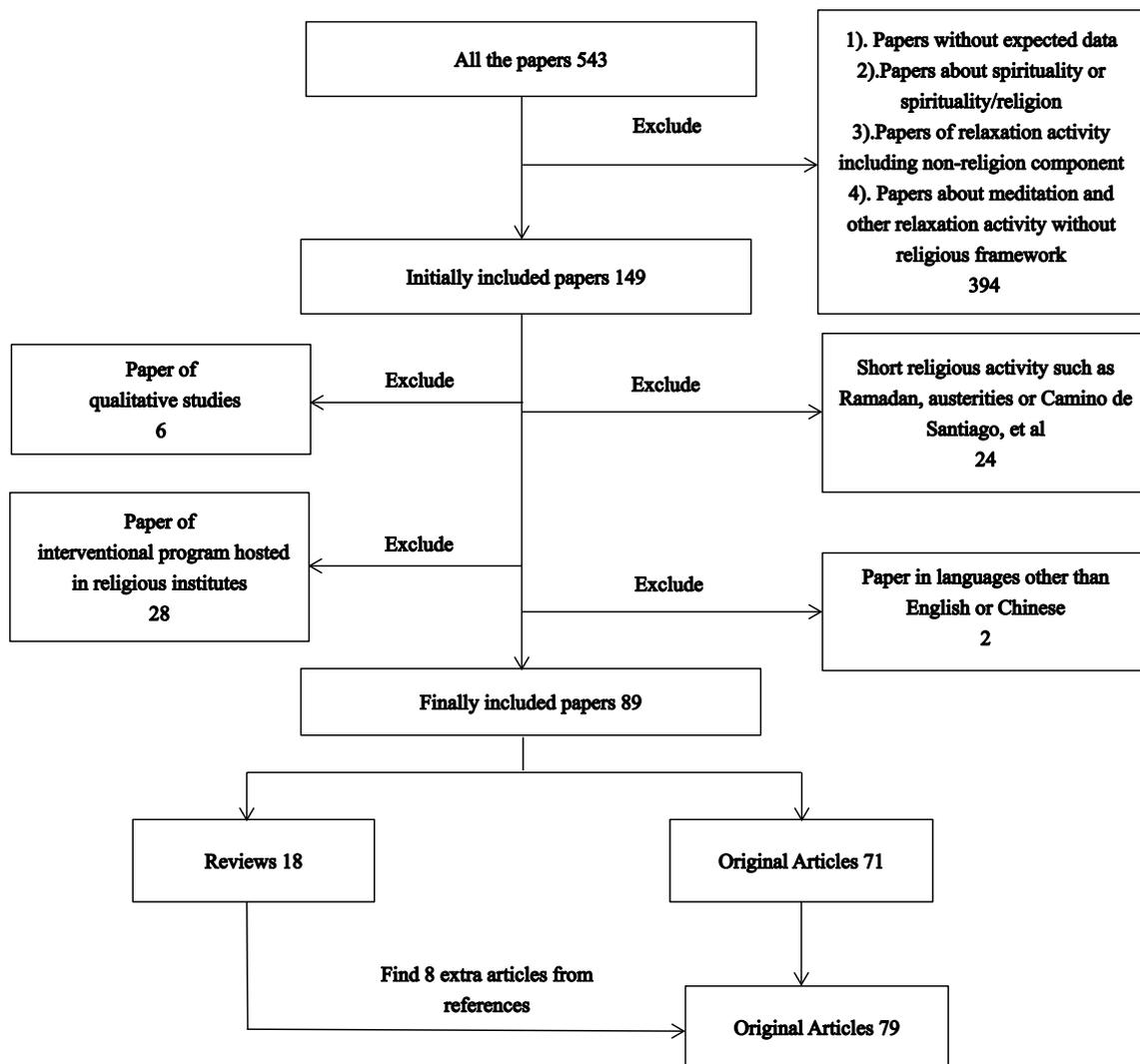


Fig. 1 The flowchart of literature retrieval and selection

hypertension/blood pressure without dividing them according to their specific types of religion/sect. The brief information of finally reviewed 39 studies is demonstrated in Table 1. All investigations were published between the year 1968 and 2016. In detail, there were 31 cross-sectional, 5 prospectively observant and 3 interventional trials, respectively. 20 in 31 cross-sectional studies (64.5%), 1 in 5 longitudinal trials (20%) and none of the interventional investigations were of high quality.

Given the large number of studies, merely the most important and representative evidence is described in detail, and the rest are briefly scanned and listed in references.

Studies measuring religion as an integral

Full-time religious staff vs ordinary residents There are only four trials concerned with full-time religious people, and

only one is prospective. Further, all the four studies are not of high quality.

In a 32-year prospective study in Italy, Timio et al. compared the blood pressure change between 144 nuns living in a secluded order at six nunneries in Umbria of Italy, and 138 healthy lay women living nearby. At the start, blood pressure and baseline data such as ethnicity, residential area, hypertensive family history, lifestyles (e.g., smoking, alcohol consumption, sodium intake represented by 24-h urinary sodium excretion) and demographic factors were comparable between the two groups. After 32 years, although there were no differences with regard to body mass index increase and menopause age, the blood pressure trend of the two groups was opposite. During the follow-up period, blood pressure remained virtually unchanged among the nuns, with none showing a rise in diastolic blood pressure (DBP) to above 90 mmHg.

Table 1 Summary of included studies about religion and hypertension

Author, year	Population source	Sample size	Sex (male %)	Age range	Age average	Race	Design	Article quality	Religious category	Religious variable and outcome	Contained mechanisms by which religion interfere with hypertension/blood pressure
Krause, 2002 [26]	Nationally representative sample of older adults in Japan	1723	43%	≥ 60	69.17	Japanese	Longitudinal	6	Unspecified	Buffering the effect from death of a loved one on hypertension, Private religious practices, NS Religious coping, NS Belief in after-life, +	NA
Timio, 2001 [27]	Nuns and lay women in Umbria of Italy	282	Female	22–58	38.2/34.7	White	Longitudinal	6	Unspecified	Nuns vs control women, +	Psychosocial factors
Kunin, 1968 [28]	Roman Catholic nuns and working women in the USA	6002	Female	15+	–	All	Cross-sectional	6	Roman Catholic	Roman catholic nuns vs working women, +	NA
Xinghui, 2015 [29]	Tibetan monks and residents in Gansu of China	2026	Male	18–70	42.00/41.65	Tibetan	Cross-sectional	7	Buddhism	Monks vs residents, +	Lifestyle
Nancy Houser, 2016 [30]	Church personnel in north-eastern Congo	670	Both (47%)	–	–	Congo	Cross-sectional	7	Christianity	Pastors vs church administrators, NS	NA
Bruce Armstrong, 1977 [35]	Seventh-day Adventists and non-adventists in Western Australia	708	Both (39.5%)	30–79	–	All	Cross-sectional	8	Christianity	Adventists vs Non-Adventist, +	Lifestyle

Table 1 (continued)

Author, year	Population source	Sample size	Sex (male %)	Age range	Age average	Race	Design	Article quality	Religious category	Religious variable and outcome	Contained mechanisms by which religion interfere with hypertension/hypertension/blood pressure
Førnebo, 1988 [36]	Residents living in the municipality of Tromsø	16,621	Both (51.0%)	20–54	–	All	Cross-sectional	7	Christianity	Adventists vs Non-Adventist, +	Lifestyle
Stavig, 1984 [37]	Asians and Pacific islanders in California	1757	Both (–)	18+	39.54	All	Cross-sectional	6	Unspecified	Religious affiliation, +	NA
Olusoji James Daniel, 2013 [40]	Urban slum dwellers in Lagos, Nigeria	964	Both (34.2%)	20–81	38.41	All	Cross-sectional	8	Unspecified	Religious vs non-religious, NS	NA
Livingston, 1991 [38]	Black Americans in Maryland State, USA	1420	Both (41.3%)	18+	–	Black	Cross-sectional	6	Unspecified	Religious affiliation, +	NA
Yechiel Friedlander, 1985 [41]	Jewish residents of Jerusalem	8646	Both (–)	17+	–	All	Cross-sectional	6	Jewish	Religiosity, NS	Lifestyle
Harris, 1981 [43]	Children of Southern California schools	7840	Both (50%)	6–16	–	All	Cross-sectional	7	Christianity	Seventh-Day Adventist children vs non-SDA children, NS	NA
Lapane, 1997 [39]	Three USA cities (PHHP)	5145	Both (44.8%)	18–64	41.1/36.9	All	Cross-sectional	9	Unspecified	Church member vs non-church member, +	NA
Saffron Karlsen, 2010 [42]	Nationally representative data from the Health Survey for England	10825	Both (44.8%)	2+	–	Unspecified	Cross-sectional	8	Christianity	Religious involvement, NS	NA

Table 1 (continued)

Author, year	Population source	Sample size	Sex (male %)	Age range	Age average	Race	Design	Article quality	Religious category	Religious variable and outcome	Contained mechanisms by which religion interfere with hypertension/blood pressure
Hixson, 1998 [44]	Alumni from Salem College and the University of North Carolina	112	Female	35–80	50.1	Whites	Cross-sectional	8	Judeo-Christian	Various religious indicators, +	Lifestyle
Walsh, 1998 [45]	Immigrants residing in the Toledo, Ohio	137	Both (54.0%)	18–71	41.9	All	Cross-sectional	6	Unspecified	Religious commitment, +	Social connection
Bell et al. 2012 [46]	USA national representative sample (NHANES III)	12,488	Both (47.5%)	20+	39.0–46.6	Non-Hispanic whites, blacks, and Mexican Americans	Cross-sectional	10	Unspecified	1. Religious services Attendance, + in Whites and black; NS in Mexican Americans; 2. Gender differences exist;	NA
Pollard, 2003 [47]	Newcastle residents with European and South Asian origin	1509	Both (European, 51.5%; South Asian, 47.5%)	25–74	European, 54.2/54.0; South Asian, 50.8/50.1	All excluding minorities in European origin	Cross-sectional	9	Unspecified	Religious worship attendance, +; Ethnicity difference exists	NA
Torgeir Sørensen, 2011 [48]	Norway, Nord-Trøndelag	37,981	Both (44.1%)	20+	53.3 male/52.4 female	All	Cross-sectional	9	Unspecified	Religious attendance in past 6 months, +; No gender difference	NA
Bland, 1991 [49]	New York, Buffalo	1409	Both (46.6%)	20–70	44.7/43.3	Whites	Cross-sectional	10	Unspecified	Religious service attendance, NS	NA

Table 1 (continued)

Author, year	Population source	Sample size	Sex (male %)	Age range	Age average	Race	Design	Article quality	Religious category	Religious variable and outcome	Contained mechanisms by which religion interfere with hypertension/hypertension/blood pressure
Joanna Maselko, 2007 [50]	Durham, East Boston, New Haven, USA (EPESE)	853	Both (46.1%)	70–80	74.0–74.4	All	Cross-sectional	10	Unspecified	Gender difference exist	NA
Jessica Tarranto, 2005 [51]	Undergraduate students	60	Both (46.7%)	21.1	17–39	All	Non-randomized controlled trial	10 (no control Group)	Unspecified	1. Religiosity, male +, female -; 2. Religious Attendance male +, female -; 3. Prayer frequency, male +, female -	NA
Buck, 2009 [24]	Chicago, USA (CCAHS)	3105	Both (40%)	18+	42.5	All	Cross-sectional	8	Unspecified	1. Religious attendance NS; 2. Private religious activity, NS; 3. Spirituality, NS;	NA
Gillum, 2006 [52]	USA national Representative Sample (NHANES III)	14,475	Both (43.9%)	20+	41–48	All	Cross-sectional	10	Unspecified	Religious services attendance, +	NA
Ananya Tina Banerjee, 2012 [53]	Canada, Saskatchewan (CCHS 4.1)	5442	Both (53%)	18+	48.1	All	Cross-sectional	9	Unspecified	Religious services attendance in past 12 months, +	NA

Table 1 (continued)

Author, year	Population source	Sample size	Sex (male %)	Age range	Age average	Race	Design	Article quality	Religious category	Religious variable and outcome	Contained mechanisms by which religion interfere with hypertension/blood pressure	
Koenig, 1998 [25] Follow-up wave 1	US North Carolina (Duke EPESE)	3145	Both (33.1%)	65+	–	All	Longitudinal	7	Unspecified	1. Religious service/meeting attendance, +; 2. Prayer, meditation or bible study, NS; 3. Religious TV or radio study, NS;	1. Religious service/meeting attendance, +; 2. Prayer, meditation or bible study, NS; 3. Religious TV or radio study, NS;	NA
Koenig, 1998 [25] Follow-up wave 2	US North Carolina (Duke EPESE)	2391	Both (32%)	65+	–	All	Longitudinal	6	Unspecified	1. Religious service/meeting attendance, +; 2. Prayer, meditation or bible study, +; 3. Religious TV or radio, NS;	1. Religious service/meeting attendance, +; 2. Prayer, meditation or bible study, +; 3. Religious TV or radio, NS;	NA
Anthony Walsh, 1987 [54]	Immigrants residing in Toledo, Ohio	137	Both (54.0%)	–	–	All	Cross-sectional	6	Unspecified	Religious attendance frequency, +	Religious attendance frequency, +	NA
Charlemagne-Badal, 2016 [55]	North America (PsyMRS)	5720	Both (32.8%)	30+	–	Blacks and whites	Longitudinal	5	Christian	Religious attendance frequency, NS	Religious attendance frequency, NS	NA
Charlemagne-Badal, 2016 [23]	North America (PsyMRS)	9581	Male (32.9%)	30+	61.45	Blacks and whites	Cross-sectional	10	Christian	1. Intrinsic religiosity, +; 2. Religious attendance frequency, NS	1. Intrinsic religiosity, +; 2. Religious attendance frequency, NS	NA

Table 1 (continued)

Author, year	Population source	Sample size	Sex (male %)	Age range	Age average	Race	Design	Article quality	Religious category	Religious variable and outcome	Contained mechanisms by which religion interfere with hypertension/blood pressure
Larson, 1989 [56]	USA (Evans County Cardiovascular Epidemiologic study)	407	Male	25+	–	Whites	Cross-sectional	8	Unspecified	1. Religious service attendance, -; 2. Importance of Religion, -; 3. Importance of religion with religious attendance, +; 4. Age and smoking status difference exist	NA
Yeager, 2006 [57]	Social Environment and Biomarkers of Aging Study (SEBAS)	944	Both (-)	–	50+	All	Cross-sectional	10	Unspecified	1. Religious service attendance, NS; 2. Religious affiliation, NS; 3. Private religious activities and religious coping, NS	NA
Levin, 1988 [58]	Journeyman air traffic controllers from new York and new England	408	Male	25–48	36.2	Whites	Cross-sectional	9	Christianity and Catholicism	1. Religious service attendance, NS; 2. Religious categories, NS;	NA
Hill, 2014 [59]	National representative sample of USA (NSHAP)	2934	Both (48%)	57–85	–	All	Cross-sectional	8	Unspecified	Religious services attendance in past 12 months, +;	Lifestyle

Table 1 (continued)

Author, year	Population source	Sample size	Sex (male %)	Age range	Age average	Race	Design	Article quality	Religious category	Religious variable and outcome	Contained mechanisms by which religion interfere with hypertension/hypertension/blood pressure
Daiiki Kobayashi, 2015 [61]	Japanese health checkup individuals	29,215	Both (-)	18+	-	All	Longitudinal	7	Unspecified	Religiosity, -	Lifestyle
Yagoub Yousif Al-Kandari, 2003 [60]	Kuwaitis	223	Both (46.6%)	18–75	29.9	Kuwaitis	Cross-sectional	4	Islam	Religious commitment, +	Lifestyle, social connection
Atikarn Gainey, 2016 [63]	Type 2 DM patients recruited from a hospital in Thailand	23	Both (17.4%)	40–75	63/58	Thailand	Randomized controlled trial	High risk:4 Unclear:1 Low risk:2	Buddhism	Before vs After Buddhist walking meditation, +	Psychosocial factors
Ratree Sudsuang, 1990 [62]	College Thai students	82	Male	20–25	-	Thailand	Non-randomized controlled trial	14 (control group exists)	Buddhism	Before vs after Buddhist meditation +	Psychosocial factors
Jui-Kun Chiang, 2013 [64]	Volunteers from health checkup clinics at a Buddhist hospital in Taiwan	706	Female	-	56.4	Taiwan	Cross-sectional	9	Buddhism	Buddhism related vegetarian vs non-vegetarian, -	NA
Steffen, 2001 [65]	Employed men and women in the Duke Behavioral Investigation Of Hypertension Study	155	Both (53.5%)	25–45	33/34	White and black	Cross-sectional	8	Unspecified	Religious coping, NS in whites, + in African Americans	Lifestyle, psychosocial factors, social connection

In the column of religious variable and outcome, + means protective for hypertension/blood pressure (HTN/BP); - means aggravating of HTN/BP; NS means non-significant. Article quality is assessed by the score of AHRQ for cross-sectional study, by the score of NOS for prospective study, by the score of MINORS for non-randomized trial, and by the score got from Cochrane Collaboration's too for the randomized trial.

In contrast, women of the control group showed increase in blood pressure with age as expected. This resulted in a great difference of more than 30/15 mmHg in blood pressure between the two groups, which was statistically significant. In each of the three age subsets, β slopes of the systolic and diastolic blood pressure were significantly higher in the control group than in the nuns [27].

Two of the other three cross-sectional trials agreed with the supportive conclusion above. In the first study, blood pressure was found to be significantly lower in Roman Catholic nuns recruited along the eastern seaboard of the USA, when compared with working women from Virginia, with an impressive magnitude of about 4–7 mmHg [28]. The second one was carried out in 984 monks and 1042 Tibetan residents in Gannan Tibetan autonomous district of Gansu Province in China, in which the overall prevalence of hypertension and blood pressure in monks was significantly lower than those of local residents [29]. However, among a sample of 670 church personnel in a large city of north-eastern Congo, pastors did not have significantly higher prevalence of hypertension compared with church administrators [30]. This might be because church administrators also work in church, thus they may be influenced by religion as well. Meanwhile, this can also be because monks/nuns and priests perform different activities. Specifically, the monks in monasteries are separated from the surrounding society and live a simple life [29]. They have no worries connected with financial problems or children's education [29]. They also have no rivalry in ascending the social ladder [29]. Similarly with the monks, nuns live in secluded orders, which is silent and isolated from the outside world [27]. Different from monks/nuns, the priests participate in secular life [31–34]. Their activities include listening to the sadness and confession of people, helping people by providing forgiveness and encouragement [31, 32], and teaching people the wisdom and dogma of the faith [33]. They also perform the sacred rituals of religion as a mediatory agent between members of the religious body and its deity, such as blessing worshipers at marriages or after a birth [32] and easing the experience of grief at funerals [32]. Unlike monks and nuns, not all priests are subject to the restriction on marriages; thus, some priests take the responsibility of family affairs [30, 34]. The cloistered life without pressure from outside world is a protector of hypertension for monks/nuns. However, the priests do not stay away from numerous things and stressful environment, which exert a harmful effect on the blood pressure.

Involvement/affiliation of religion or not All the evidence stemmed from cross-sectional data. Five in nine were high-quality studies, and also five in nine supported the opinion that religious affiliation was related to decreased hypertension prevalence/blood pressure. Moreover, most of these tri-

als were based on special populations, which can explain their divergence and limit their representativeness.

In both Western Australia and Norway, the blood pressures in vegetarian Seventh-day Adventists were lower than in non-Adventists [35, 36]. The beneficial role of religious affiliation was also found among Asians and Pacific islanders in California [37], as well as in 1420 black Americans who were part of a larger sample of 6717 adults interviewed in the 1981–82 Maryland Statewide Hypertension Control Program [38]. Further, as a part of the evaluation of the Pawtucket Heart Health Program (PHHP), baseline survey data from Pawtucket, Rhode Island, and Massachusetts reveal significantly lower diastolic blood pressures among church members than non-church members [39].

In studies conducted among urban slum dwellers in Lagos of Nigeria, religion was not significantly associated with hypertension after covariates were adjusted [40]. Similar results were found not only in Jewish residents of Jerusalem in whom no differences in adjusted systolic and diastolic blood pressure were observed between different religious groups (either men or women) [41], but also in white British people from health surveys whose belief in Christianity did not produce a significantly lower risk of hypertension [42]. In addition, the lack of blood pressure difference between SDA and non-SDA children in southern California schools is explicable since there is a long latent period, before exposure to the factors relevant to blood pressure turns into the first appearance of elevated blood pressure [43].

Organized religious index There are two investigations probing into the organized religious index that combines two or more indicators into a comprehensive one.

Hixon et al. conducted an investigation of 112 female alumni of Salem College and University of North Carolina [44]. The participants were at least 35 years of age, who revealed the protective effect on diastolic blood pressure exerted by total religiosity, which is a combination of intrinsic religiosity, extrinsic religiosity, belief factor, religious well-being, organized religious activity, non-organized religious activity, religious knowledge, religious experience, as well as religious coping [44]. Similarly, church attendance and religious importance were combined into one index called “religious commitment” by Walsh et al. to investigate 137 immigrants residing in the Toledo, Ohio [45], in which the salutary role of religious commitment on lower rates of hypertension and lower systolic and diastolic blood pressure levels was reported [44].

Studies measuring specific aspects of religion

Religious service attendance This is the most commonly used indicator. There were 18 researches investigating the relationship between religious services attendance (RA)

and hypertension/blood pressure. 16 (88.9%) were cross-sectional studies, and 1 longitudinal and 1 non-randomized interventional study, respectively. 15 (83.3%) of these studies were of high quality. Although more than 50% of the trials revealed a salutary effect of religious service attendance on hypertension, the conclusions were inconsistent among various populations.

First of all, the effects of increased attendance at religious services on hypertension/BP are not the same among populations from different races. From the Third National Health and Nutrition Examination Survey (NHANES III) that used a nationally representative data set of the USA, both non-Hispanic whites who attended services weekly and blacks who attended more than weekly had lower odds of hypertension, when compared with those who never attended services. However, the association between attendance and hypertension did not exist among Mexican Americans [46]. Similarly, attendance was inversely related to systolic blood pressure (SBP) for all groups, but more for whites and blacks compared to Mexican Americans [46]. In Newcastle residents of European origin, there was no BP difference between religious worship attenders and non-attenders, while it was approximately significant that the DBP of attenders was higher than non-attenders in residents of South Asian origin [47]. This is partially due to ethnic differences in the genetic background of hypertension. Further, it may also possibly be attributed to the racial variation in attendance frequency and the extent of religiosity. For example, in some races, protective effects of social support may be obtained from family rather than from increased exposure to friends from increased attendance at religious services.

Secondly, the association is not always uniform in both gender groups. Although the surveys in Nord-Trøndelag of Norway [48] and Buffalo of New York [49] demonstrate consistent relationship between religious attendance and BP in both men and women [48], when it comes to NHANES III, gender does modify the correlation between attendance and hypertension among blacks and Mexican Americans, such that an inverse relationship is observed among black women instead of black men, and Mexican American men (not women) who are infrequent attendees have higher odds of hypertension [46]. Similarly, gender diversity also existed among older adults aged 70–80 years with high-functional ability, who were selected from communities of three sites of the Established Population for Epidemiologic Studies of the Elderly (EPESE) cohort, i.e., Durham, East Boston and New Haven [50]. Among those older men, weekly service attendance was associated with higher SBP, while such correlation was not found in older women [50]. Further, among 60 young undergraduate students, Tartaro et al. found that higher frequency of attendance at religious services was associated with lower BP in males and elevated BP in females [51]. Some people may attend services out

of obligation, guilt or fear, in whom negative emotion may appear, such as feelings of being punished by God, anger at God, conflicts with other congregation members, anxiety or depression, which could result in BP elevation. Since the proportion of these people may differ between genders in some populations, the interaction of gender with religious attendance on hypertension/BP does sometimes exist.

The relationship of RA–BP may also be influenced by urban/rural factor. In a local sample of urban Chicago, significant difference in BP between frequent and infrequent attendees was not found [24]. However, an inversely significant relationship was discovered using the US national data that includes both urban and rural adults [52]. Both populations were multi-ethnic and shared similar gender composition. Since it is less possible to buffer the stresses with other social resources in this setting, it is plausible that the rural environment may allow RA to have a greater impact on BP.

Populations sampled from different parts of the world may vary widely with regard to the above factors, such as ethnicity, gender composition, urbanization and some not measured elements that probably play a role, e.g., natural environment, lifestyles, cultural context, socioeconomic status, education, occupation and identity. All these differences among various regions may cause distinct findings on the relationship between RA and BP. For example, in Nord-Trøndelag, a rural county situated in the middle of Norway, a large survey of all inhabitants aged 20 years and over revealed that religious attendance was independently associated with lower SBP and DBP [48]. Evaluation of an urban sample in Saskatchewan ($n = 5442$) from the Canadian Community Health Survey (CCHS 4.1) also demonstrated that persons who attended religious services more than once a week exhibited a lower prevalence of self-reported hypertension, compared to persons who attended less than once a year [53]. Similarly, negative correlation between religious service attendance and blood pressure was found in a sample of 3964 persons aged 65 years or older, from five contiguous counties (1urban, 4 rural) of central North Carolina [25], in 137 immigrants residing in Toledo of Ohio [54], as well as in 112 females alumni of Salem College and University of North Carolina who are at least 35 years old [44]. Religious service attendance did not significantly correlate with BP in 1401 white adults aged 20–70 years, who studied in Buffalo City of New York [49]. Non-significant result also existed in a cross-sectional study of 9581 older North American Seventh-day Adventists, and in its successive follow-up investigation (534 newly occurring higher hypertension at 4 years follow-up), using data from the Psychological Manifestations of Religion Sub-study (PsyMRS) [23] [55]. Non-significant effect of religious service attendance on blood pressure are reported in 407 adult white rural men participating in the Evans County, Georgia, Cardiovascular Study [56], in older Taiwanese from Social Environment and

Biomarkers of Aging Study (SEBAS) [57] and also in 406 male journeyman air traffic controllers randomly selected from various locations throughout New York and New England who participated in the Air Traffic Controller Health Change (ATC) Study [58].

Moreover, the result of national investigation which involves people from different regions can be interpreted as a synthesized consequence. Such investigations included NHANES III [52] and NSHAP [59], which used USA national samples of 14,475 adult participants and 2934 elderly people (aged 57–85), respectively. In both of them, religious attendance was inversely associated with decreased blood pressure [52] [59] or reduced prevalence of hypertension [52].

Above all, the association between religious service attendance and hypertension/BP is determined by the population studied. That's because a specific population has unique characteristics in aspects of ethnicity, gender structure, region urbanization, et al. All these features may imply the population's unique genetic background, religious tradition, psychology status, living environment, etc. which may exert effect on the mechanism underlying hypertension or decide people's reaction to a religion. Therefore, it is suggested that a specific population should be particularly examined with regard to the RA–BP correlation in the future.

Intrinsic religiosity There were seven articles evaluating intrinsic religiosity and hypertension/blood pressure. There were five cross-sectional studies [24, 44, 56, 60], four of which (80%) were high-quality trials [23, 24, 44, 56]. The one prospectively observant study was also of high quality [61], and the other was a non-randomized controlled study in which the overall blood pressure level instead of blood pressure change was used as the dependent variable [51].

Intrinsic religiosity refers to the emphasis which an individual places on faith or the centrality of religion in a person's life. It is assessed in two ways. One uses scales that measure the importance of religion to someone, or an effort to integrate religion into all aspects of life, for example, the Duke University Religion Index (DUREL) [23] or scales developed by the researcher themselves [44, 60]. The other directly evaluates the extent of religiousness in someone by asking “(how much) religious are you?” or “how important is religion to you?” [24, 51, 56, 61].

Distinct results exist among various participants even in the same study. Larson and colleagues examined 407 adult white rural men participating in the Evans County, Georgia, Cardiovascular Study, in which the comparison of mean SBP and DBP between those with high religious importance and those with low religious importance demonstrates a non-significant consequence [56]. However, after stratification of the sample by age, with 55 years as the cutoff, only in

the older age group did the differences in blood pressures between high and low importance groups approach statistical significance. Similarly, only in smokers did the inverse correlation exist between blood pressure and religious importance [56].

Further, there are different correlations between religiosity and hypertension/BP among various populations. Supportive correlations have been proved in some samples. In cross-sectional data from the Psychological Manifestations of Religion Sub-study (PsyMRS), intrinsic religiosity was directly related to lower hypertensive rates among 9581 older North American Seventh-day Adventists, even after controlling demographics, lifestyle variables and church attendance [23]. The intrinsic religiosity measured using Duke University Religion Index (DUREL) scale is at least as important as and is possibly more important to hypertension than lifestyle factors [23]. Among 112 women, Hixson et al. studied the relationship between religiosity and blood pressure using Koenig's religiosity instrument, and intrinsic religiosity was found to be one of the two predictors that was directly and most strongly associated with lower blood pressure [44]. Similarly, a Kuwait survey of 223 Muslims revealed the protective role of Islam commitment to blood pressure, which was measured by a scale evaluating someone's emphasis on religion through observing the rules [60]. Using 60 undergraduate students, Tartaro et al. measured religiosity by asking “to what extent do you consider yourself a religious person?” [51]. Higher values on religiosity are associated with lower blood pressure in men and higher blood pressure in women [51]. On the other hand, there are no significant associations in other populations. Using data taken from the Chicago Community Adult Health Study, in a sample of 3105 adults aged 18 years and over living in the city of Chicago, religious saliency that assessed how much participants carry religion into their life was not related to BP or hypertension [24]. In a retrospective cohort study that was conducted involving 36,965 Japanese individuals who underwent annual health checkups at St. Luke's International Hospital from 2005 to 2010, religiosity was not longitudinally associated with future hypertension [61].

Private religious activity Private religious activities include prayer, Buddhist meditation, scripture learning, watching religious TV or listening to religious radio.

First of all, different types of private religious activity do not necessarily exert the same effects in a certain sample. For example, in a prospective investigation conducted among 3964 older persons participating in the Duke EPESE (Establishment of Populations for Epidemiologic Studies of the Elderly) survey, lower DBP was observed among those who frequently (daily or more often) prayed, meditated or studied the Bible, watched religious TV or listened to religious radio [25]. Therefore, it is easy to

understand the existence of divergence in investigations that vary in both private religious activity and the studied population. With regard to Buddhist meditation, two interventional studies found consistently supportive results. In 52 Thai males (20–25 years old) practising Dhammakaya Buddhist meditation for 2–4 h a day during summer vacation, blood pressures were significantly reduced after meditation, while no decline was observed in the control group of 30 Thai males (with the same age) who did not practise meditation [62]. Similarly, Gainey et al. randomly allocated 23 patients with mild type 2 diabetes into ‘traditional walking exercise group’ and ‘Buddhist walking meditation exercise group’ [63]. Both groups performed a 12-week exercise program that mainly consisted of walking on the treadmill, while in the ‘Buddhist walking meditation exercise group’, the participants performed walking while concentrating on foot stepping by voicing “budd” and “Dha” as each foot step contacted the floor, to practice mindfulness [63]. After 12 weeks, significant decrease in both systolic and diastolic blood pressure was observed only in the ‘Buddhist walking meditation exercise group’ [63]. Vegetarian behavior related to Buddhism was not associated with reduced SBP or reduced risk for hypertension in 706 females from health checkup clinics at a Buddhist hospital in Taiwan [64]. This may be attributed to the high proportion (80.9%) of ovo-lacto-vegetarians in this sample, who are not ‘pure vegetarians’ and consume egg and milk as supplement to animal protein [64]. Using data from a sample of 3105 adults living in Chicago, USA, Buck et al. reported that more frequent prayer was associated with an increased likelihood of hypertension [24].

Secondly, two other studies have examined the comprehensive effect of several activities, and both of them have demonstrated non-significant results. The first one is a prospective study that focuses on a nationally representative sample of 1723 older Japanese people, containing 304 people who experienced the death of a loved one [26]. The overall private religious practice, such as praying, worshiping ancestors, reading sacred scriptures, watching or listening to religious programs, was not found to buffer the deleterious effects of bereavement on hypertension [26]. The second one used data from a nationally representative survey of older Taiwanese [57]. A significant relationship did not exist between private religious practices and SBP/DBP [57]. The private religious practices in this study are a combination of actual actions and religious coping. Most of them are about particular actions, since they are evaluated based on questions asking respondents how often they: (1) pray, burn incense, worship gods or Buddha at home, (2) read scriptures, (3) watch or listen to religious programs on TV or radio, (4) pray to the Lord, gods or Buddha when they meet with some difficulty or to help them feel more peaceful, (5) ask for guidance from the Lord, gods or Buddha before

making important decision and (6) pray to the Lord or to gods to relieve worry and stress [57].

Religious coping Most of the time, religious coping refers to someone’s seeking and deriving spiritual support such as comfort, courage or consultation from his/her religious belief when faced with challenging life events (e.g., illness, loss of loved one).

Similar to the situation of other religious indicators, different results of the correlation between religious coping and hypertension/BP also exist in various populations, including both within a specific study and among distinct studies.

In 155 middle-aged men and women who participated in the Duke Bio-behavioral Investigation of Hypertension study, religious coping was significantly and inversely related to BP, both in the clinic and during ambulatory BP monitoring among African Americans, while it was not related to BP among whites [65]. In this study, religious coping is assessed by a subscale which consists of four items: I put my trust in God, I seek God’s help, I try to find comfort in religion and I pray more than usual [65]. It is possible that religious coping might represent the most effective coping tool available for African Americans who have limited resources, while the whites have higher education and income that might bring greater availability to resources that help buffer stress [65].

Religious coping, as one particular aspect assessed by a 33-question multidimensional scale, had the greatest impact on BP in 112 female alumni of Salem College and University of North Carolina [44]. However, no significant effect of religious coping was found in the Chicago Community Adult Health Study (CCAHS) that investigated 3105 adults in Chicago [24]. Positive religious coping in this study was measured using a two-item index which includes: (1) ‘I work together with God as partners’ and (2) ‘I look to God for strength, support, and guidance’ [24]. Association between religious coping and longitudinal hypertension did not exist in another prospective study with a nationally representative sample of 1723 Japanese older people containing 304 people who experienced bereavement [26]. Religious coping in this Japanese study was evaluated by three indicators that assessed whether respondents turned to a deity during difficult times, whether they consulted one of the gods when adversity arose and whether they asked a deity to help them overcome the stressors [26].

Belief in eternal life Three studies including two longitudinal ones have evaluated the role of ‘belief in eternal life’ or ‘belief in existential certainty’ [24, 26, 57].

The Chicago Community Adult Health Study (CCAHS), a cross-sectional study that measures several indicators among 3105 adults in Chicago, also assessed belief in eternal life and its consequence was not significant [24].

Two longitudinal trials were conducted in Asia. Survey of older Taiwanese from the Social Environment and Biomarkers of Aging Study (SEBAS) measures ‘belief in eternal life’ by four questions that assess whether someone believes the existence of heaven and hell, the immortality of spirit, the role of a death as passage to paradise, as well as the beauty of afterlife [57]. Finally, a non-significant relationship was found between religious beliefs and blood pressure in this population [57]. On the contrary, the other study conducted in Japan obtained an opposite conclusion [26]. Older people from Japan who experienced the death of a loved one and simultaneously believed in a good afterlife were less likely to report that they had hypertension at the follow-up interview than those who lost a close one without believing in a good afterlife [26]. This trial especially emphasises ‘existential certainty’ that comprises the faith that life after life is much better than life on earth, and death is just one point on the way to eternal happiness [26]. The belief that the deceased was going to a better place particularly provided a great deal of comfort to this sample, which consisted of people who were suffering from sadness of bereavement; it could provide relaxation and reduce hypertensive risk [26].

Other indicators There are few other indicators. Further, these indicators are gathered in two investigations that evaluate religion from various dimensions [24] [44].

For example, Buck et al. has used public religious activities and spiritual attendance beliefs [24]. Specifically, public religious activity measures whether respondents identify themselves as active members in non-worship religious activities (e.g., serving on a committee or helping organize meetings) and whether respondents have held a leadership position in the congregation (e.g., Sunday school teacher or deacon) within the past 5 years [24]. Spiritual attendance belief is a three-item index, which measures respondents’ religious feelings about attending services, such as faith

renewing, sense of inner peace and feeling of God’s presence [24]. It is considered that the salutary relationship between religious service attendance and hypertension/BP may stem from individuals’ belief that spiritual and social benefits can originate from religious service attendance [24]. Although no significant correlation has been found between these two indicators and hypertension/BP, they are regarded as novel indicators that help to analyze the complex relationship systematically [24].

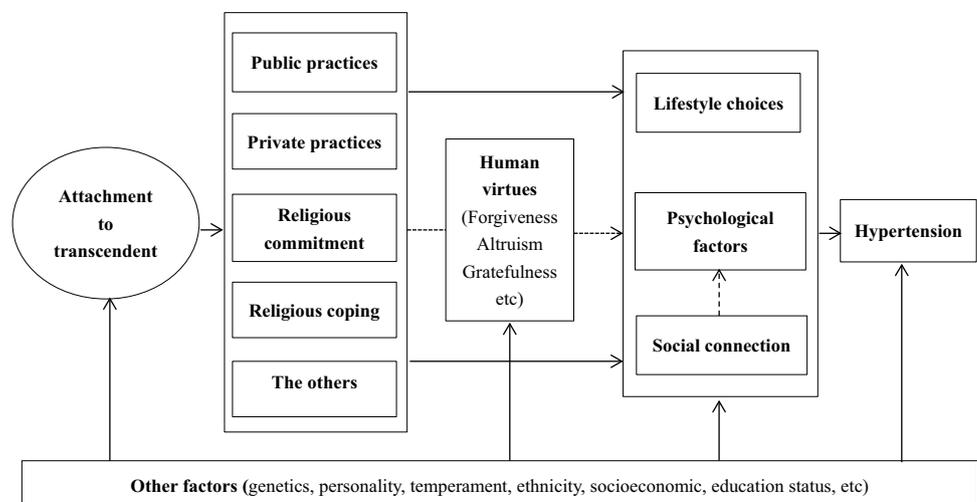
The other study that used religious indicators was conducted in 112 female alumni of Salem College and University of North Carolina [44]. It creates several innovative indicators, such as belief factor, which describes the acceptance degree to the prescribed doctrines, religious well-being, which assesses religious satisfaction, religious knowledge, which reflects understanding about religious beliefs/writings/rituals, religious experiences, which mean occasions defined as an encounter between believers and some supernatural consciousness, as well as extrinsic religiosity, which refers to utilitarian of being religious (e.g., useful for the self in granting safety, social standing, solace and endorsement for one’s chosen way of life) [44]. All the indicators were found to have negative correlation with blood pressure [44].

Mechanism and explanation of religion and hypertension

Based on previous reviews about religion and health [2, 3], in combination with the hypertensive characteristics and the evidence from trials, the theoretical mechanism of religion and hypertension is elaborated using a multifactorial model in this section (Fig. 2).

As Fig. 2 displays, the primitive core of a religion is the attachment to the transcendent being, and most religious traditions expressly relate it to this world feelings, institutions and behaviors [9]. Therefore, the belief about the

Fig. 2 Theoretical model of religion and hypertension



transcendent being is manifested in life by public religious practices (attending religious services and other social religious activity), private religious activities (prayer, meditation, reading religious scriptures, etc.), intrinsic religious commitments, religious coping and others. From these aspects, religions further act on lifestyle, psychological emotion and social connection, which importantly influence the factors for blood pressure [66–69]. Although there may be other pathways correlating religion and hypertension, the above three are basic and primary ones, which can be studied using the methods of science [3]. Specifically, 13 of the finally included 39 articles (33.3%) provide data about the correlation between religion and the above-mentioned influencing factors, i.e., the mediators between religion and hypertension/blood pressure [27, 29, 35, 36, 41, 44, 45, 59–63, 65]. Further, two articles simultaneously contain more than one mediator [60, 65]. One article (7.7%) simultaneously contains both lifestyle and social connection as the mediators [60], while the other one (7.7%) contains lifestyle, psychosocial factors and social connection as the mediators [65]. All the remaining 11 articles only contain one mediator. In detail, seven (53.8%) [29, 35, 36, 41, 44, 59, 61], three (23.1%) [27, 62, 63] and one (7.7%) [45] article, respectively, contain the role of lifestyles, psychosocial factors and social connection as the mediators. The last column of Table 1 displays the specific category of mediator demonstrated in each article.

First of all, lifestyle is one of the most important influencing factors of hypertension [66]. Religions encourage the respect for one's body, discouraging risky behaviors by doctrines that promote body care (as the "temple of the Holy Spirit" in the Christian tradition, for example) [3]. There are specific regimens which are sanctioned by religious traditions as well [9]. There is ample evidence that religion plays a beneficial role in hypertension-related lifestyles such as healthy diet [18, 29, 35, 36, 41, 43, 44] [65], smoking quitting [29, 35, 41, 60, 61, 44], alcohol abstinence [29, 35, 44, 60, 65], exercise involvement [55] and lower BMI [29, 59]. However, religious individuals are also reported to engage in negative health behaviors (e.g., less exercise [70, 71]) and demonstrate higher weight [61, 72–76].

Secondly, high blood pressure is linked with psychosocial factors [25, 27]. Healthy or mature religion may benefit psychological dimensions of one's life [56]. Therefore, the second theory proposes that religious involvement may exert its blood pressure lowering effect through a psycho-physiologically mediated processes [44, 56]. According to previous evidence, religion can boost favorable factors such as a sense of security [60] and well-being [61], inner peace [27, 44], forgiveness [24, 56], self-esteem [65], meaning and purpose [24], life satisfaction [25] and selflessness [56]. Meanwhile, religions also can neutralize negative psychological burdens such as depression [25, 65], anxiety [25, 65] and lower

authoritarianism [23]. Recent studies have reported an association between religious practices and better coping with stressful life experiences, which brings relaxation [25, [26, 51, 56, 65]. Further, some religious activity such as Buddhist meditation can elicit tranquility and relaxation from mindfulness practices [62, 63]. Although religion improves psychological status in most of the time, sometimes it also can cause dreadful emotion because it justifies human shortcomings such as hatred, aggression and prejudice, fosters rigid thinking and obsessive practices, causes anxiety and fear due to punishment threat on evil deeds and also produces mental strains because of the failure to reach high religious standards [2, 77].

Third, there is evidence that social connections have beneficial effects on blood pressure [9, 37]. Religious commitment leads to social connection, thus leading to lower blood pressure [45, 60, 65]. This can be explained because many religious communities often have well-established rules for relating to one another and place a heavy emphasis on positive relationships [56]. Religious service attendance can promote more frequent contacts with larger social networks and enhance social integration [24, 50]. Besides, religion also helps to cultivate the "human virtues" including forgiveness [24, 56], honesty [78–83], humility, gratefulness [84, 85] and kindness [86], which can further facilitate social connection. However, exclusion of others and escape from dealing with family problems through excessive involvement in religious activities can also be caused by religion occasionally [2].

11 of the 39 finally included articles have provided data confirming correlation among religion, mediators (lifestyles, psychosocial factors, social connection) and hypertension/blood pressure level [27, 29, 35, 36, 44, 45, 59, 60, 62, 63, 65]. The detailed information is extracted and displayed in Table 2, including the features of the subjects, the study methods, related results and related conclusions.

In addition, the correlation of religion and hypertension is simultaneously impacted by other factors, such as genetics, personality and socioeconomic and educational status. These influencing factors exert their effect either directly on hypertension itself, or through indirect factors such as religion affiliation chosen, human virtue promotion or social connections [2, 3, 9].

Above all, the relationship between religion and hypertension is extremely complex.

Summary and perspective

Above all, the published trials on correlation of religion and hypertension are few in number, but have inconsistencies. First of all, prospective studies, especially those of high quality, are scarce. Second, trials that evaluate religion as

Table 2 Summary of religion and its mediators for hypertension/blood pressure

Author, year	Type of mediator	Features of subjects	Study methods	Related results	Related conclusions
Timio, 2001 [27]	Psychosocial factors	<ol style="list-style-type: none"> 1. Subject origin: nuns and lay women in Umbria of Italy 2. Sample size: 144/138 for nuns/lay women 3. Age range: 22–58 4. Age mean: 38.2/34.7 for nuns/lay women 5. Gender proportion: Female 100% 	<ol style="list-style-type: none"> 1. Design: longitudinal design (after initial observation, a 32-year follow-up was undertaken) 2. Data: obtained from interview, physical examination, and blood (lipid profiles, etc.) and 24 h-urine (urinary free adrenaline and noradrenaline, etc.) sample measurement. During follow-up, all women underwent periodic visits 3. Analysis: multiple regression analysis for continuous measures was assessed and comparisons between the two groups were estimated using the slope of the regression line (β coefficient). Repeated-measures ANOVA was also used to compare the two groups over the 32-year follow-up 	<ol style="list-style-type: none"> 1. For the baseline, SBP (125.6 ± 5.9 vs 128.2 ± 7.4, NS) and DBP (79.1 ± 4.1 vs 81.0 ± 4.4, NS) of the nuns are similar with that of laywomen 2. The β slope of the SBP and DBP increase with age was significantly higher in the control women than in the nuns for each age subsets ($p < 0.01$ for all age subsets) 3. In the nuns, slope of both SBP and DBP generally approximate to zero regression equations of SBP and DBP on age in nuns and the control women 4. Urinary adrenaline (3.9 ± 2.0 vs 5.8 ± 2.7, $p < 0.05$) and noradrenaline is lower in nuns than in laywomen at baseline (13.6 ± 4.6 vs 18.1 ± 4.8, $p < 0.05$). Urinary adrenaline and noradrenaline levels remained lower in the nuns than in the laywomen over the observational time 	<ol style="list-style-type: none"> 1. During the follow-up period, blood pressure remained stable among the nuns, and none showed a rise in DBP to above 90 mmHg. By contrast, the control lay women showed expected increase in blood pressure with age 2. It appears reasonable to attribute much of the difference in blood pressure to the different burden in psychosocial factors

Table 2 (continued)

Author, year	Type of mediator	Features of subjects	Study methods	Related results	Related conclusions
Xinghui Li, 2015 [29]	Lifestyle	<ol style="list-style-type: none"> Subjects origin: Tibetan monks and residents selected by random sampling, in Gansu of China Sample size: 984 monks/1042 residents Age range: 18–70 Mean age: 42.00/41.65 Gender proportion: 100% male in both groups) 	<ol style="list-style-type: none"> Design: Cross-sectional Data: Obtained from interview, physical examination, sodium intake (calculated from the total amount of salt consumed by a unit members) and dietary assessment (24-h dietary recall, macronutrients determined using 2002 Chines food composition tables) Analysis: Blood pressure comparison between two groups in each stratification by age or BMI or education level stratification, using <i>t</i> test. Comparison of lifestyle related variables between two groups, using <i>t</i> test and Chi square test 	<ol style="list-style-type: none"> Tibetan residents had higher blood pressure than monks in each level stratified by age, BMI and educational level, respectively ($p < 0.05$ to $p < 0.01$) BMI, smoking, alcohol consumption, intakes of total energy, fat, protein, and salt is lower in monks than that of residents ($p < 0.05$ to $p < 0.01$) 	<ol style="list-style-type: none"> Blood pressure is significantly lower in monks than in local residents Relatively healthy lifestyle is the major contributing factor for the difference of blood pressure between two groups

Table 2 (continued)

Author, year	Type of mediator	Features of subjects	Study methods	Related results	Related conclusions
Bruce Armstrong, 1977 [35]	Lifestyle	<ol style="list-style-type: none"> Subjects origin: Vegetarian Seventh-day Adventists (SDA) and non-SDA in Narrogin, a Western Australian town Sample size: 418 SDA and 290 non-SDA Age range: 30–79 Gender proportion: 42.3% male in SDAs/35.5% male in non-vegetarians 	<ol style="list-style-type: none"> Design: Cross-sectional Data: Obtained from self-administered questionnaire, physical examination, biochemistry test (plasma cholesterol and uric acid, and hematologic variables, serum vitamin B12 and serum folate) Analysis: The overall mean systolic and diastolic BPs in both groups were adjusted for the effects of sex, age, height and weight by covariance analysis 	<ol style="list-style-type: none"> The mean systolic and diastolic BPs in the SDAs, adjusted for age, sex, height and weight (128.7/76.2 mm of mercury) are significantly less than those in the Narrogin residents (non-SDA) (139.3/84.5), $p < 0.01$ Age-adjusted percentage of ever smoked tobacco, current alcohol consumption, current tea or coffee consumption, eggs and meat intake are lower in SDA than in non-SDA, both in male and female stratification In SDA, when age, sex, height and weight were controlled, the mean DBP in those who drank tea and/or coffee was 83.6 mmHg vs 75.4 mmHg in those who did not ($p < 0.01$) with adjustment for sex, age, height and weight demonstrated a consistent gradient in mean BP from 121.5 mm (< 1 egg/month) to 132.0 systolic (≥ 1 egg daily) and 72.1 mmHg to 78.0 mmHg DBP (both $p < 0.05$) 	<ol style="list-style-type: none"> Blood pressure is significantly lower in SDA than in non-vegetarians The lifestyle difference may explain the blood pressure difference between SDA and non-SDA

Table 2 (continued)

Author, year	Type of mediator	Features of subjects	Study methods	Related results	Related conclusions
V Fønnebø, 1988 [36]	Lifestyle	<ol style="list-style-type: none"> 1. Subject origin: Residents living in the municipality of Tromsø 2. Sample size: 16,621 3. Age range: 20–54 4. Gender proportion: 51.0% male 	<ol style="list-style-type: none"> 1. Design: Cross-sectional 2. Data: Obtained from self-administered questionnaire, Physical examination, biochemical test (total cholesterol, high-density lipoprotein cholesterol, tri-glycerides, and glucose.) 3. Analysis: age-adjusted blood pressure by sex and religious group. Percentage of coffee drinkers and regular ground meat and fish consumers by sex and religious group 	<ol style="list-style-type: none"> 1. Blood pressure was lower in Seventh-day Adventists than in non-SDA, except the DBP of males 2. The blood pressure is lower among religiously active SDA than in nonactive SDA for both sexes 3. In two religiously similar groups, religiously active SDA and Baptists, the blood pressure of Baptists is higher than that of religiously active SDA, except the DBP of males 4. In each gender, there was a difference in intake of animal products and coffee between the Seventh-day Adventists and non-Seventh-day Adventists, indicating that between 20 and 40% of SDA in Troms were vegetarians 5. In each gender, Baptists and religiously nonactive SDA had a dietary pattern very similar to the general population which means higher intake of animal products and coffee than that of religiously active SDA 	<ol style="list-style-type: none"> 1. Blood pressure is lower in SDA than in non-SDA, lower in active SDA than in nonactive SDA, lower in active SDA than in Baptist 2. The blood pressure difference may arise from the effect of diet

Table 2 (continued)

Author, year	Type of mediator	Features of subjects	Study methods	Related results	Related conclusions
Hixson, 1998 [44]	Lifestyle	<ol style="list-style-type: none"> 1. Subject origin: Alumni from salem college and the university of North Carolina 2. Sample size: 112 3. Age range: 35–80 4. Age mean: 50.1 5. Gender proportion: 100% female 	<ol style="list-style-type: none"> 1. Design: cross-sectional design 2. Data: obtained from questionnaire (including a multifactorial questionnaire used to assess various dimensions of religiosity, and some scales measuring lifestyles such as exercise, diet, smoking, etc.), physical examination 3. Analysis: Multiple regression path analyses are conducted to determine direct and indirect effects of religiosity (each nine of the religiosity and total religiosity score) on SBP/DBP. Standardized partial coefficients of multiple regression analysis (age and BMI were controlled statistically) were used to estimate all the path coefficients. Direct effect of religiosity on BP was equal in magnitude to the path coefficient between religiosity variable and blood pressure. Each indirect effect was calculated as the product of the path coefficients between religiosity variable and health behavior variable and the path coefficient between the health behavior variable and BP. The overall indirect effect was equal to the sum of indirect effects for all the paths leading through health behavior variables 	<ol style="list-style-type: none"> 1. The total effect (-0.018) and indirect effect (-0.011) of total religiosity on SBP are negative, as well as on DBP (total effect -0.166, indirect effect -0.026) 2. All the nine dimensions of religiosity have negatively total effect on DBP, and 6 of the 9 dimensions have negatively total effect on SBP. 8 of the 9 dimensions have negatively indirect effect on DBP, and 6 of the 9 dimensions have negatively indirect effect on SBP 3. Only intrinsic religiosity is demonstrated as an example. The total effect of intrinsic religiosity on DBP is -0.218. It has negative effect on alcohol consumption (standardized $\beta = -0.021$), smoking (standardized $\beta = -0.001$), and diet (standardized $\beta = -0.004$) 	<ol style="list-style-type: none"> 1. Religiosity has protective role for blood pressure 2. Lifestyle factors such as alcohol consumption, smoking and diet may be the mediators

Table 2 (continued)

Author, year	Type of mediator	Features of subjects	Study methods	Related results	Related conclusions
Anthony Walsh, 1998 [45]	Social connection	<ol style="list-style-type: none"> 1. Subject origin: Immigrants residing in the Toledo, Ohio 2. Sample size: 137 3. Age range: 18–71 4. Age mean: 41.9 5. Gender proportion: Male 54% 	<ol style="list-style-type: none"> 1. Design: Cross-sectional design 2. Data: Obtained from interview (including scale measured assimilation and anomie), physical examination 3. Analysis: Logistic regression analysis is used to determine relationship between religious commitment and hypertension adjusting and confounding factors. Pearson correlation was used to evaluate the correlation between religious commitment and social support indicators (assimilation and anomie) 	<ol style="list-style-type: none"> 1. In logistic regression analysis, religious commitment had a unique effect on the probability of hypertension, using either the SBP ($\beta = -2.664$, OR 0.98, $p < 0.01$) or DBP ($\beta = -2.319$, OR 0.84, $p < 0.01$) criteria after adjusting for the effects of other relevant variables, can be seen in these findings 2. In Pearson correlation, religious commitment is significantly related to both measures of social support: the religiously committed were more assimilated ($r = 0.33$, $p < 0.01$) and were less anomie ($r = -0.18$, $p < 0.05$) 	<ol style="list-style-type: none"> 1. Religious commitment, which leads to lower blood pressure 2. Social support reflected by assimilation and anomie may be the mediators between religious commitment and blood pressure
Hill, 2014 [59]	Lifestyle	<ol style="list-style-type: none"> 1. Subject origin: National representative sample of USA (NSHAP) 2. Sample size: 2934 3. Age range: 57–85 4. Gender proportion: 48% male 	<ol style="list-style-type: none"> 1. Design: Cross-sectional design 2. Data: Obtained from face-to-face interviews, physical examination 3. Analysis: multivariate logistic regression analysis and Multivariate linear regression analysis, both adjusting age, gender, race/ethnicity, education, and income 	<ol style="list-style-type: none"> 1. In binary logistic regression analysis, religious attendance is inversely associated with diastolic blood pressure. Each unit increase in religious attendance reduces the odds of high diastolic blood pressure (versus low to moderate diastolic blood pressure) by 9% (OR = 0.91, CI 0.82–0.99). 2. In multivariate linear regression analysis, religious attendance is negatively associated with BMI ($r = -0.001$, $p < 0.01$) 	<ol style="list-style-type: none"> 1. Higher levels of religious attendance are associated with lower levels of diastolic blood pressure 2. Higher levels of religious attendance are associated with lower levels of BMI, which may be a contributing factor

Table 2 (continued)

Author, year	Type of mediator	Features of subjects	Study methods	Related results	Related conclusions
Yagoub Yousif Al-Kandari, 2003 [60]	Lifestyle, social connection	<ol style="list-style-type: none"> 1. Subject origin: Kuwaitis 2. Sample size: 223 3. Age range: 18–75 4. Age mean: 29.9 5. Gender proportion: 46.6% male 	<ol style="list-style-type: none"> 1. Design: Cross-sectional analysis 2. Data: Obtained from questionnaire, and physical examination 3. Analysis: Multivariate regression analysis was conducted to determine the effect of religiosity on blood pressure, statistically controlling for other variables such as body mass index, socioeconomic status, smoking, gender and age. Spearman rank correlation analysis was conducted to determine the association between religiosity and smoking, relatives close to you, friends close to you. 	<ol style="list-style-type: none"> 1. In multivariate regression analysis, after adjusting for the effect of these variables, there remains a relationship between religious commitment and systolic ($\beta = -0.092, p < 0.05$) and diastolic blood pressure ($\beta = -0.154, p < 0.05$) 2. In Spearman rank correlation, religiosity is significantly negative with smoking ($r = -0.167, p < 0.05$), significantly positive with the number of close relatives ($r = 0.458, p < 0.01$) and friends ($r = 0.356, p < 0.01$) 	<ol style="list-style-type: none"> 1. It's found that both systolic and diastolic blood pressure were negatively affected by religious commitment 2. Religiosity is correlated with less smoking and better social connection reflected by more close relatives and friends

Table 2 (continued)

Author, year	Type of mediator	Features of subjects	Study methods	Related results	Related conclusions
Ratree Sudsuang, 1990 [62]	Psychosocial factors	<p>1. Subject origin: College Thai students</p> <p>2. Sample size: 82</p> <p>3. Age range: 20–25</p> <p>4. Gender proportion: Male 100%</p>	<p>1. Design: Non-randomized Controlled trial. Intervention group consists of 52 males 20–25 years of age practicing Dhammakaya Buddhist meditation for 2 months. Control group consists of 30 males of the same age without practicing meditation</p> <p>2. Data: Obtained from self-report questionnaire, physical examination, blood analysis (including serum cortisol and other indicators)</p> <p>3. Analysis: Measurement were performed before meditation program, at 3 weeks and at 6 weeks into the program. Statistical comparisons between pre and post tests were conducted using paired Student's <i>t</i> test</p>	<p>1. Only in intervention group, SBP (pre vs post: 114.02 ± 8.91 vs 109.22 ± 11.55, $p < 0.01$) and DBP (pre vs post: 73.96 ± 7.09 vs 67.80 ± 7.83, $p < 0.01$) decreased significantly after 6 week into the program. In control group, there's no significant change on SBP (pre vs post: 115.16 ± 12.14 vs 116.83 ± 7.93, NS) or DBP (pre vs post: 75.66 ± 7.73 vs 76.33 ± 6.68, NS)</p> <p>2. Only in intervention group, blood cortisol level (pre vs post: 11.43 ± 2.59 vs 9.85 ± 1.91, $p < 0.01$) decreased significantly after 6-week into program. In control group, there's no significant change on blood cortisol level (pre vs post: 11.39 ± 1.64 vs 11.43 ± 1.39, NS)</p> <p>3. Only in intervention group, heart rate (pre vs post: 82.17 ± 9.13 vs 75.46 ± 8.89, $p < 0.01$) decreased significantly after 6-week into program. In control group, there's no significant change on heart rate (pre vs post: 80.26 ± 5.24 vs 80.73 ± 7.72, NS)</p>	<p>1. Buddhism meditation can decrease blood pressure</p> <p>2. The blood pressure decrease is likely to be elicited by tranquility and relaxation from the Buddhism meditation</p>

Table 2 (continued)

Author, year	Type of mediator	Features of subjects	Study methods	Related results	Related conclusions
Atikarn Gainey, 2016 [63]	Psychosocial factors	<p>1. Subject origin: Type 2 DM patients recruited from hospital in Thailand</p> <p>2. Sample size: 23 (11 in interventional group and 12 in control group)</p> <p>3. Age range: 40–75</p> <p>4. Age mean: 63/58 in interventional/control groups</p> <p>5. Gender proportion: 18, 18 and 16.67% in interventional and control groups, respectively</p>	<p>1. Design: randomized controlled trial. Subjects were randomly allocated into two groups, and performed a 12-week exercise program. One group performed traditional walking exercise (WE), the other performed Buddhism-based walking meditation exercise (WM). Change of blood pressure, blood cortisol, and other indicators are measured</p> <p>2. Data: Obtained from self-report questionnaire, physical examination, blood analysis (including blood glucose, HbA1c, lipid profile, plasma cortisol, etc.)</p> <p>3. Analysis: Statistical comparisons between pre and post tests were conducted using paired Student's <i>t</i> test</p>	<p>1. Only in Buddhism-based walking meditation exercise group, SBP (pre vs post: 145 ± 5 vs 128 ± 5, $p < 0.05$) and DBP (pre vs post: 85 ± 2 vs 78 ± 2, $p < 0.05$) decreased significantly after 12-week exercise</p> <p>2. Only in Buddhism-based walking meditation exercise group, blood cortisol level (pre vs post: 9.6 ± 1.1 vs 6.1 ± 0.5, $p < 0.05$) decreased significantly after 12-week exercise</p>	<p>1. Buddhism-based walking meditation can decrease blood pressure</p> <p>2. The blood pressure decrease is likely to be elicited by tranquility and relaxation from the Buddhism-based walking meditation</p>

Table 2 (continued)

Author, year	Type of mediator	Features of subjects	Study methods	Related results	Related conclusions
Steffen, 2001 [65]	Lifestyle, psychosocial factors, social connection	<p>1. Subject origin: Employed men and women participating in Duke Biobehavioral investigation of hypertension study. Subjects taking any cardiovascular medications or using tobacco products were excluded from the study. Subjects with SBP \geq 180 mmHg or DBP \geq 100 mmHg were excluded.</p> <p>2. Sample size: 155</p> <p>3. Age range: 25–45</p> <p>4. Age mean: 33–34</p> <p>5. Gender proportion: 53.5% male</p>	<p>1. Design: cross-sectional design</p> <p>2. Data: obtained from questionnaire (including scales measuring religious coping, depression, anxiety, social support), physical examination (including both clinic and ambulatory blood pressure monitoring)</p> <p>3. Analysis: hierarchical multiple regression analysis of religious coping predicting awake/sleep SBP among African Americans. Pearson's correlation coefficients were first used to identify potential mediators of the relationship between BP and religious coping.</p>	<p>1. Multiple regression analyses, controlling for confounding variables, religious coping was not related to BP among whites. Among African Americans, however, higher levels of religious coping were associated with lower awake ($r = -0.27, p < 0.05$) and sleep ($r = -0.33, p < 0.01$) ABP</p> <p>2. Among African Americans, higher levels of religious coping were related to higher perceived social support satisfaction ($r = 0.30, p < 0.01$), and less alcohol consumption ($r = 0.36, p < 0.01$). There was a trend for lower depressive symptoms ($r = -0.24, p = 0.06$)</p> <p>3. Social support satisfaction also was related to lower awake ABP among African Americans ($r = -0.23$ for SBP, $p < 0.06$, $r = -0.27$ for DBP, $p < 0.01$)</p>	<p>1. Among African Americans, religious coping remained as significant determinant of both awake and sleep BP, after accounting for the effects of confounding variables</p> <p>2. Lifestyle, psychosocial factors and social connection are possible mediators</p>

integral are scarce, although they can assess religions most comprehensively. Third, different indicators measure distinct dimensions of religions; however, not many studies use several religious measurements. Moreover, even assessed by a specific evaluator, divergence exists in correlation of religion and hypertension among diverse populations. Further, 59% studies are assigned to an unspecified type of religion, and in those with a specific category of religion, Christianity is mostly studied while other religions are infrequently investigated. Finally, the possible mechanism underlying religion and hypertension is quite complex with many factors involved, which can partly explain the results' difference among various populations.

Comprehensive evaluation of a religion or the use of multiple variables representing several religious dimensions may yield a better understanding. In addition, for a specific population, the correlation between religion and hypertension should be examined particularly, no matter similar investigation in other populations have been conducted or not. Finally, more evidence focused on the effects of distinct religions/sects categories is needed.

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Compliance with ethical standards

Conflict of interest None.

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